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**ELECTRONIC TUBE MANUAL****REGISTRATION PAGE**

Mr. John Davidson
York Div.
Bendix Aviation Corp.
York, Pa.

ET-116E

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General Electric Company
Schenectady 5, New York

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ELECTRONIC COMPONENTS DIVISION**GENERAL  ELECTRIC**

Schenectady 5, N. Y.

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Tube Manual Preview

A Summary of the Contents of Supplement No. 25 to the Transmitting Tube Manual

This supplement includes data on one new voltage-tunable magnetron and revised data on four tubes.

NEW TYPES

GL-7398

Packaged voltage-tunable magnetron designed for voltage-tunable operation in the 2200- to 3850-megacycle frequency range. The tube is a high-frequency oscillator with applications in receiving and transmitting equipment. The package consists of three units: VTM tube, a radio-frequency circuit or cavity, and a magnet, all aligned and locked together to form an integral unit. It has a CW power output of 2 watts across the frequency range and an anode voltage rating of 1250 volts at 3000 megacycles.

REVISIONS

GL-870-A

The data sheet has been revised to the current form for presenting data on phanotrons. There are no rating changes.

GL-5973

Test data has been added to the Description and Rating sheet.

GL-6283

A new class of service has been added—Radio-Frequency Power Amplifier—Class B Linear. Under this class of service the power output is 110 watts, carrier level, with a d-c plate voltage of 1750 volts.

GL-6897

Under electrical the transconductance, amplification factor and direct interelectrode capacitance ratings have been revised. The outline has been revised.

Selection Chart—Transmitting Tubes

Revised so that the types reflect tubes now in the Power Tube line.



ELECTRONIC TUBE MANUAL INDEX

All Manuals

This Index indicates the particular manual which contains complete data on any tube. For convenience, the tubes are listed in alpha-numerical order. For listings by class refer to the Table of Contents sheet in each volume.

Tube Type	Class	Manual*			Tube Type	Class	Manual*		
OA2	Glow Tube	F			GL-1P40	Phototube			
OA3	Glow Tube	F			GL-1Q26-A	Reference Cavity		T	
OA4-G	Gas Triode	F			1R5	Heptode	R		
OB2	Glow Tube	F			1S2-A	Rectifier			
OB3	Glow Tube	F			1S4	Pentode	R		
OC3	Glow Tube	F			1S5	Diode-Pentode	R		
OD3	Glow Tube	F			1T4	Pentode	R		
OZ4	Diode	R			1U4	Pentode	R		
OZ4-A	Twin Diode	F			1U5	Diode-Pentode	R		
OZ4-G	Diode	R			1V2	Diode	R		
KC-1	Rectifier				1V6	Triode-Pentode	R		
1A5-GT	Pentode	R			1X2-A	Diode	R		
1A7-GT	Pentagrid Converter	R			1X2-B	Diode	R		
1AD4	Pentode				2A3	Triode	R		
1AG4	Beam Pentode	R			2AF4	Triode	R		
1AH4	Pentode	R			2AF4-A	Triode	R		
1AJ5	Diode-Pentode	R			GL-2B22	Diode		T	
1AX2	Diode	R			GL-2B23	Rectifier			
1B3-GT	Diode	R			2BN4	Triode	R		
1DN5	Diode-Pentode	R			GL-2C39-B	Triode		T	
1G3-GT	Rectifier				GL-2C40	Triode		T	
1H5-GT	Diode-Triode	R			GL-2C40-A	Triode		T	
1J3	Diode	R			GL-2C42	Triode			
1K3	Diode	R			GL-2C43	Triode		T	
1L4	Pentode	R			GL-2C46	Triode			
1L6	Pentagrid Converter	R			2CY5	Tetrode	R		
GL-1L21	Vacuum Capacitor				2D21	Thyratron		F	
GL-1L24	Vacuum Capacitor				2E24	Beam Pentode		F	
GL-1L25	Vacuum Capacitor				2E26	Beam Pentode		F	
GL-1L31	Vacuum Capacitor				2E30	Beam Pentode		F	
GL-1L32	Vacuum Capacitor				GL-2H21	Phasitron			
GL-1L33	Vacuum Capacitor				2X2-A	Diode		F	
GL-1L36	Vacuum Capacitor				KC-3	Rectifier			
GL-1L38	Vacuum Capacitor				3A2	Diode	R		
1LA6	Pentagrid Converter	R			3A3	Diode	R		
1LH4	Diode-Triode	R			3AF4-A	Triode	R		
1LN5	Pentode	R			3AL5	Twin Diode	R		
1N5-GT	Pentode	R			3AU6	Pentode	R		
GL-1P21	Phototube				3AV6	Duplex-Diode Triode	R		
GL-1P39	Phototube				3B2	Diode	R		

* R = Receiving Manual
F = Five-Star and Special-Purpose Manual
T = Transmitting Manual

ELECTRONIC COMPONENTS DIVISION

GENERAL ELECTRIC

Schenectady 5, N. Y.

Supersedes ET-T1216A dated 11-56

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Tube Type	Class	Manual*	Tube Type	Class	Manual*
GL-3B24W	Rectifier		5CG8	Triode-Pentode	R
3BA6	Pentode	R	5CL8-A	Triode-Tetrode	R
3BC5	Pentode	R	5CQ8	Triode-Pentode	
3BE6	Heptode	R	5CZ5	Beam Power	
3BN4	Triode	R	5DH8	Triode-Pentode	R
3BN6	Gated-Beam	R	5EA8	Triode-Pentode	R
3BU8	Twin Pentode	R	5J6	Twin Triode	R
3BY6	Heptode	R	5R4-GYA	Twin Diode	F
3BZ6	Pentode	R	5T8	Triple-Diode Triode	R
GL-3C22	Triode		5U4-GA	Twin Diode	R
GL-3C23	Thyratron	I	5U4-GB	Twin Diode	R
3CB6	Pentode	R	5U8	Triode-Pentode	R
3CE5	Pentode	R	5V3	Rectifier	
3CF6	Pentode	R	5V4-GA	Twin Diode	R
3CS6	Heptode	R	5V6-GT	Pentode	R
3DK6	Pentode		5X8	Triode-Pentode	R
3DT6	Pentode	R	5Y3-GT	Diode	R
3Q4	Pentode	R	5Y3-WGTB	Service Designation†	
3Q5-GT	Pentode	R	5Y4-GT	Twin Diode	R
3S4	Pentode	R	5Z3	Diode	R
3V4	Pentode	R	6A7	Pentagrid Converter	R
GL-3X2500A3	Triode		6A8	Pentagrid Converter	R
PJ-4	Triode		6AB4	Triode	R
4AU6	Pentode		6AC5-GT	Triode	R
4BC8	Twin Triode	R	6AC7	Pentode	R
4BN6	Gated-Beam	R	6AC7-WA	Service Designation†	
4BQ7-A	Twin Triode	R	6AC7-Y	Pentode	
4BS8	Twin Triode	R	6AD7-G	Triode-Pentode	R
4BU8	Twin Pentode	R	6AF3	Diode	
4BZ6	Pentode	R	6AF4	Triode	R
4BZ7	Twin Triode	R	6AF4-A	Triode	R
4CB6	Pentode	R	6AG5	Pentode	R
4CS6	Heptode	R	6AG7	Pentode	R
4CY5	Tetrode	R	6AG7-Y	Pentode	
GL-4D21/4-125A	Tetrode		6AH4-GT	Triode	R
4DT6	Pentode	R	6AH6	Pentode	R
GL-4X150A	Tetrode		6AK5	Pentode	R
GL-4-1000A	Tetrode-Pentode		6AK6	Pentode	R
5AM8	Diode-Pentode	R	6AL5	Twin Diode	R
5AN8	Triode-Pentode	R	6AL7-GT	Electron-Ray Indicator	R
5AQ5	Beam Pentode	R	6AM4	Triode	R
5AS4	Twin Diode	R	6AM8	Diode-Pentode	R
5AS8	Diode-Pentode	R	6AN5	Beam Power	R
5AT8	Triode-Pentode	R	6AN8	Triode-Pentode	R
5AU4	Twin Diode	R	6AQ5	Beam Pentode	R
5AV8	Triode-Pentode	R	6AQ5-A	Beam Pentode	R
5AW4	Twin Diode	R	6AQ6	Duplex-Diode Triode	R
5B8	Triode-Pentode	R	6AQ7-GT	Duplex-Diode Triode	R
5BE8	Triode-Pentode	R	6AR5	Pentode	R
5BK7-A	Twin Triode	R	6AR8	Sheet Beam	R
5BQ7-A	Twin Triode	R	6AS5	Beam Power	R
5BR8	Triode-Pentode	R	6AS6	Pentode	R
5BT8	Double-Diode Pentode		6AS7-GA	Twin Triode	R
GL-5C21/C6J	Thyratron		6AS8	Diode-Pentode	R
GL-5C24	Triode		6AT6	Duplex-Diode Triode	R

* I=Industrial Manual

R=Receiving Manual

F=Five-Star and Special-Purpose Manual

† Because of the special nature of this type, data sheets are not maintained. Refer to the applicable Armed Service specifications for ratings.

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Tube Type	Class	Manual*	Tube Type	Class	Manual*
6AT8.....	Triode-Pentode.....	R	6C5.....	Triode.....	R
6AU4-GTA.....	Diode.....	R	6C6.....	Pentode.....	R
6AU5-GT.....	Beam Pentode.....	R	6CA5.....	Beam Pentode.....	R
6AU6-A.....	Pentode.....	R	6CB5-A.....	Beam Pentode.....	R
6AU6-WA.....	Service Designation†.....		6CB6-A.....	Pentode.....	R
6AU8-A.....	Triode-Pentode.....	R	6CD6-GA.....	Beam Pentode.....	R
6AV5-GA.....	Beam Pentode.....	R	6CE5.....	Pentode.....	R
6AV6.....	Duplex-Diode Triode.....	R	6CF6.....	Pentode.....	R
6AW8-A.....	Triode-Pentode.....	R	6CG7.....	Twin Triode.....	R
6AX4-GT.....	Diode.....	R	6CG8-A.....	Triode-Pentode.....	R
6AX5-GT.....	Diode.....	R	6CH8.....	Triode-Pentode.....	
6AZ8.....	Triode-Pentode.....	R	6CK4.....	Triode.....	
6B8.....	Duplex-Diode Pentode.....	R	6CL6.....	Pentode.....	R
6BA6.....	Pentode.....	R	6CL8-A.....	Triode-Tetrode.....	R
6BA7.....	Pentagrid Converter.....	R	6CM6.....	Beam Pentode.....	R
6BA8-A.....	Triode-Pentode.....	R	6CM7.....	Double Triode.....	R
6BC5.....	Pentode.....	R	6CN7.....	Duplex-Diode Triode.....	R
6BC7.....	Triple Diode.....	R	6CQ8.....	Triode-Tetrode.....	
6BC8.....	Twin Diode.....	R	6CR6.....	Diode-Pentode.....	R
6BD6.....	Pentode.....	R	6CS6.....	Heptode.....	R
6BE6.....	Heptode.....	R	6CS7.....	Double Triode.....	
6BF5.....	Beam Power.....	R	6CU5.....	Beam Power.....	R
6BF6.....	Duplex-Diode Triode.....	R	6CU6.....	Beam Pentode.....	R
6BG6-GA.....	Beam Pentode.....	R	6CU8.....	Triode-Pentode.....	
6BH6.....	Pentode.....	R	6CX8.....	Triode-Pentode.....	R
6BH8.....	Triode-Pentode.....	R	6CY5.....	Tetrode.....	R
6BJ6.....	Pentode.....	R	6CY7.....	Double Triode.....	R
6BJ7.....	Triple Diode.....	R	6CZ5.....	Beam Power.....	
6BJ8.....	Double-Diode Triode.....		6D4.....	Thyratron.....	F
6BK4.....	Beam Triode.....	R	6D6.....	Pentode.....	R
6BK5.....	Beam Pentode.....	R	6DA4.....	Diode.....	R
6BK7-B.....	Twin Triode.....	R	6DB5.....	Beam Pentode.....	
6BL7-GTA.....	Twin Triode.....	R	6DE6.....	Pentode.....	R
6BN4.....	Triode.....	R	6DG6-GT.....	Beam Pentode.....	R
6BN6.....	Gated-Beam.....	R	6DK6.....	Pentode.....	R
6BN8.....	Double-Diode Triode.....		6DN7.....	Double Triode.....	R
6BQ5.....	Power Pentode.....		6DQ5.....	Beam Power.....	
6BQ6-GA.....	Pentode.....	R	6DQ6-A.....	Beam Pentode.....	R
6BQ6-GTB.....	Beam Pentode.....	R	6DS5.....	Beam Power.....	
6BQ7-A.....	Twin Triode.....	R	6DT6.....	Pentode.....	R
6BR8.....	Triode-Pentode.....	R	6E5.....	Electron-Ray Indicator.....	R
6BS8.....	Twin Triode.....	R	6EA8.....	Triode-Pentode.....	R
6BU8.....	Twin Pentode.....	R	6EB8.....	Triode-Pentode.....	
6BV8.....	Duplex-Diode Triode.....	R	6EH8.....	Triode-Pentode.....	
6BW4.....	Rectifier.....		6EW6.....	Pentode.....	R
6BW8.....	Duplex-Diode Pentode.....	R	6F5.....	Triode.....	R
6BX7-GT.....	Twin Triode.....	R	6F6.....	Pentode.....	R
6BY4.....	Triode.....	R	6F6-GT.....	Pentode.....	R
6BY5-GA.....	Twin Diode.....		6H6.....	Twin Diode.....	R
6BY6.....	Heptode.....	R	6J4.....	Triode.....	R
6BY8.....	Pentode.....		6J5.....	Triode.....	R
6BZ6.....	Pentode.....	R	6J6.....	Twin Triode.....	R
6BZ7.....	Twin Triode.....	R	6J7.....	Pentode.....	R
6BZ8.....	Twin Triode.....	R	6K6-GT.....	Pentode.....	R
6C4.....	Triode.....	R	6K7.....	Pentode.....	R

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Tube Type	Class	Manual*	Tube Type	Class	Manual*
6K8	Triode-Hexode	R	7B5	Pentode	R
6L6	Beam Power	R	7B6	Duplex-Diode Triode	R
6L6-GB	Beam Power	R	7B7	Pentode	R
GL-C6M	Thyratron	—	7B8	Pentagrid Converter	R
6N7	Twin Triode	R	7C5	Beam Power	R
6Q7	Duplex-Diode Triode	R	7C6	Duplex-Diode Triode	R
6S4-A	Triode	R	7C7	Pentode	R
6S8-GT	Triode-Diode Triode	R	GL-7C29	Triode	—
6SA7	Pentagrid Converter	R	GL-7D21	Tetrode	T
6SA7-Y	Pentagrid Converter	—	7EY6	Pentode	R
6SB7-Y	Pentagrid Converter	R	7F7	Twin Triode	R
6SC7	Twin Triode	R	7F8	Twin Triode	R
6SF5	Triode	R	7F8-TV	Twin Triode	—
6SF7	Diode-Pentode	R	7H7	Pentode	R
6SG7	Pentode	R	7J7	Triode-Heptode	R
6SG7-Y	Pentode	—	7K7	Duplex-Diode Triode	R
6SH7	Pentode	R	7N7	Twin Triode	R
6SJ7	Pentode	R	7Q7	Pentagrid Converter	R
6SJ7-Y	Pentode	—	7S7	Triode-Heptode	R
6SK7	Pentode	R	7Y4	Diode	R
6SK7-WA	Service Designation†	—	7Z4	Diode	R
6SK7-Y	Pentode	—	8AU8-A	Triode-Pentode	R
6SL7-GT	Twin Triode	R	8AW8-A	Triode-Pentode	R
6SN7-GTB	Twin Triode	R	8BQ5	Pentode	—
6SQ7	Duplex-Diode Triode	R	8CG7	Twin Triode	R
6SR7	Duplex-Diode Triode	R	8CM7	Double Triode	R
6SS7	Pentode	R	8CN7	Duplex-Diode Triode	R
6SV7	Diode-Pentode	R	8CS7	Double Triode	—
6T4	Triode	R	8CX8	Triode-Pentode	R
6T8	Triode-Diode Triode	R	8EB8	Triode-Pentode	—
6T8-A	Triode-Diode Triode	R	9CL8	Triode-Tetrode	R
6U5	Electron-Ray Indicator	R	9U8-A	Triode-Pentode	R
6U8	Triode-Pentode	R	10C8	Triode-Pentode	R
6U8-A	Triode-Pentode	R	10DE7	Double Triode	—
6V3-A	Diode	R	11CY7	Double Triode	R
6V6	Beam Power	R	12A6	Beam Power	R
6V6-GT	Pentode	R	12A8-GT	Pentagrid Converter	R
6V6-GTY	Beam Power	—	12AB5	Beam Pentode	R
6V6-Y	Receiving	—	12AC6	Pentode	R
6W4-GT	Diode	R	12AD6	Heptode	R
6W6-GT	Beam Pentode	R	12AE6	Duplex-Diode Triode	R
6X4	Twin Diode	R	12AF3	Diode	—
6X4-WA	Service Designation†	—	12AF6	Pentode	R
6X5-GT	Diode	R	12AJ6	Duplex-Diode Triode	—
6X8	Triode-Pentode	R	12AL5	Twin Diode	R
6Y6-G	Beam Power	R	12AL8	Triode-Tetrode	—
6Y6-GT	Beam Pentode	R	12AQ5	Beam Power	R
7A4	Triode	R	12AT6	Duplex-Diode Triode	R
7A6	Twin Diode	R	12AT7	Twin Triode	R
7A7	Pentode	R	12AT7-WA	Service Designation†	—
7A8	Octode	R	12AU6	Pentode	R
7AF7	Twin Triode	R	12AU7	Twin Triode	R
7AG7	Pentode	R	12AU7-A	Twin Triode	R
7AU7	Twin Triode	R	12AV5-GA	Beam Pentode	R
7B4	Triode	R	12AV6	Duplex-Diode Triode	R

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Tube Type	Class	Manual*			Tube Type	Class	Manual*		
12AV7.....	Twin Triode.....	R			12SG7.....	Pentode.....	R		
12AW6.....	Pentode.....	R			12SG7-Y.....	Pentode.....			
12AX4-GTA.....	Diode.....	R			12SH7.....	Pentode.....	R		
12AX7.....	Twin Triode.....	R			12SJ7.....	Pentode.....	R		
12AY7.....	Twin Triode.....		F		12SK7.....	Pentode.....	R		
12AZ7.....	Twin Triode.....	R			12SK7-Y.....	Pentode.....			
12B4-A.....	Triode.....	R			12SL7-GT.....	Twin Triode.....	R		
12BA6.....	Pentode.....	R			12SN7-GTA.....	Twin Triode.....	R		
12BA7.....	Pentagrid Converter.....	R			12SQ7.....	Duplex-Diode Triode.....	R		
12BD6.....	Pentode.....	R			12SR7.....	Duplex-Diode Triode.....	R		
12BE6.....	Heptode.....	R			12V6-GT.....	Pentode.....	R		
12BF6.....	Duplex-Diode Triode.....	R			12W6-GT.....	Beam Pentode.....	R		
12BH7-A.....	Twin Triode.....	R			12X4.....	Twin Diode.....	R		
12BK5.....	Beam Pentode.....	R			14A7.....	Pentode.....	R		
12BL6.....	Pentode.....	R			14AF7.....	Twin Triode.....	R		
12BN6.....	Gated Beam.....	R			14B6.....	Duplex-Diode Triode.....	R		
12BQ6-GA.....	Pentode.....	R			14Q7.....	Pentagrid Converter.....	R		
12BQ6-GTB.....	Beam Pentode.....	R			14R7.....	Duplex-Diode Pentode.....	R		
12BR7.....	Diode-Triode.....	R			14S7.....	Triode-Heptode.....	R		
12BV7.....	Pentode.....	R			17AX4-GT.....	Diode.....	R		
12BY7-A.....	Pentode.....	R			17D4.....	Diode.....	R		
12BZ7.....	Twin Triode.....	R			17DQ6-A.....	Beam Pentode.....	R		
12C5.....	Beam Pentode.....	R			17H3.....	Diode.....	R		
12CA5.....	Beam Pentode.....	R			18A5.....	Beam Pentode.....	R		
12CN5.....	Pentode.....				19AU4-GTA.....	Diode.....	R		
12CR6.....	Diode-Pentode.....	R			19BG6-GA.....	Beam Pentode.....	R		
12CT8.....	Triode-Pentode.....	R			19J6.....	Twin Triode.....	R		
12CU5.....	Beam Power.....	R			19T8.....	Triple-Diode Triode.....	R		
12CU6.....	Beam Pentode.....	R			21EX6.....	Receiving.....			
12CX6.....	Pentode.....				24A.....	Tetrode.....	R		
12D4.....	Diode.....	R			25AV5-GA.....	Beam Pentode.....	R		
12DB5.....	Beam Pentode.....				25AX4-GT.....	Diode.....	R		
12DE8.....	Receiving.....				25BQ6-GA.....	Pentode.....	R		
12DK7.....	Double-Diode Tetrode.....				25BQ6-GTB.....	Beam Pentode.....	R		
12DL8.....	Receiving.....				25C5.....	Beam Pentode.....	R		
12DQ6-A.....	Beam Pentode.....	R			25C6-G.....	Beam Power.....			
12DQ7.....	Pentode.....	R			25CA5.....	Beam Pentode.....	R		
12DV8.....	Duplex-Diode Tetrode.....	R			25CD6-GB.....	Beam Pentode.....	R		
12DZ6.....	Pentode.....	R			25CU6.....	Beam Pentode.....	R		
12EA6.....	Pentode.....	R			25DN6.....	Beam Pentode.....	R		
12EG6.....	Receiving.....				25EC6.....	Beam Pentode.....	R		
12F8.....	Duplex-Diode Pentode.....	R			25L6-GT.....	Beam Pentode.....	R		
12H6.....	Twin Diode.....	R			25W4-GT.....	Diode.....	R		
12J5.....	Triode.....	R			25W6-GT.....	Beam Pentode.....	R		
12J8.....	Double-Diode Tetrode.....				25Z5.....	Diode.....	R		
12K5.....	Tetrode.....	R			25Z6-GT.....	Diode.....	R		
12K7-GT.....	Pentode.....	R			26.....	Triode.....	R		
12K8.....	Triode-Hexode.....	R			27.....	Triode.....	R		
12L6-GT.....	Beam Pentode.....	R			FG-27-A.....	Thyratron.....			
12R5.....	Beam Pentode.....	R			28D7.....	Twin Beam Power.....	R		
12SA7.....	Pentagrid Converter.....	R			32L7-GT.....	Diode Beam Power.....	R		
12SA7-Y.....	Pentagrid Converter.....				35A5.....	Beam Power.....	R		
12SC7.....	Twin Triode.....	R			35B5.....	Beam Power.....	R		
12SF5.....	Triode.....	R			35C5.....	Beam Power.....	R		
12SF7.....	Diode-Pentode.....	R			35L6-GT.....	Beam Power.....	R		

* I = Industrial Manual
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Tube Type	Class	Manual*			Tube Type	Class	Manual*		
35W4	Diode	R			807	Beam Pentode	F		
35Y4	Diode	R			GL-809	Triode			
35Z3	Diode	R			GL-810	Triode			
35Z5-GT	Diode	R			GL-811-A	Triode			
41	Pentode	R			GL-812-A	Triode			
42	Pentode	R			GL-813	Pentode			
47	Pentode	R			GL-814	Beam Power			
50A5	Beam Power	R			GL-815	Beam Power			
50B5	Beam Power	R			GL-816	Rectifier			
50C5	Beam Pentode	R			GL-828	Pentode			
50DC4	Diode	R			GL-829-B	Pentode			
50L6-GT	Beam Pentode	R			GL-832-A	Beam Power			
50X6	Diode	R			GL-833-A	Triode			
50Y6-GT	Diode	R			GL-836	Rectifier			
50Y7-GT	Diode	R			GL-837	Pentode			
58	Pentode	R			GL-838	Triode			
70L7-GT	Diode Beam Power	R			GL-845	Triode			
75	Duplex-Diode Triode	R			GL-851	Triode	T		
78	Triode	R			GL-857-B	Rectifier	T		
80	Twin Diode	R			GL-862-A	Triode	T		
FG-81-A	Thyratron				GL-866-A	Rectifier			
83	Diode	R			GL-868	Phototube			
84/6Z4	Diode	R			GL-869-B	Rectifier	T		
FG-97	Thyratron	I			GL-870-A	Rectifier	T		
FG-98-A	Thyratron				GL-872-A	Rectifier	T		
GL-100TH	Triode				GL-880	Triode	T		
FG-105	Thyratron	I			884	Thyratron	F		
117N7-GT	Diode Beam Power	R			885	Thyratron			
117Z3	Diode Beam Power	R			GL-889-A	Triode	T		
117Z6-GT	Diode	R			GL-889R-A	Triode	T		
FG-154	Thyratron				GL-893A-R	Triode			
FG-172	Thyratron	I			GL-898-A	Triode	T		
GL-207	Triode				GL-918	Phototube			
GL-242-C	Triode				GL-919	Phototube			
GL-266-B	Rectifier				GL-920	Phototube			
FG-280	Rectifier				GL-921	Phototube			
SA-302	Triode				GL-922	Phototube			
SA-350	Triode				GL-923	Phototube			
GL-393-A	Thyratron	I			GL-927	Phototube			
FP-400	Rectifier				GL-929	Phototube			
GL-411	Rectifier				GL-930	Phototube			
GL-414	Thyratron				GL-931-A	Phototube			
GL-441	Phototube				GL-1000T	Triode			
502-A	Thyratron		F		GL-1454	Phototube			
GL-575-A	Rectifier	I		T	1612	Heptode	F		
GL-592	Triode				1614	Beam Pentode	F		
Z-599	Magnetron				GL-1616	Rectifier			
GL-627	Thyratron				GL-1619	Pentode			
GL-672-A	Thyratron				1620	Pentode	F		
GL-673	Rectifier	I		T	2050	Thyratron	F		
GL-678	Thyratron				GL-5513	Triode	T		
GL-801-A	Triode				GL-5516	Beam Pentode			
GL-802	Pentode				GL-5518	Triode	T		
GL-803	Pentode				GL-5528/C6L	Thyratron			
GL-805	Triode				GL-5544	Thyratron	I		

* I = Industrial Manual
R = Receiving Manual
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GL-5550	Ignitron	I	GL-5728	Thyratron	I
GL-5551-A	Ignitron	I	GL-5736	Triode	
GL-5552-A	Ignitron	I	GL-5740	Triode	
GL-5553-B	Ignitron	I	5749	Five-Star	F
GL-5554	Ignitron	I	5749/6BA6W	Service Designation†	
GL-5555	Ignitron	I	5750	Five-Star	F
GL-5556	Triode	I	5750/6BE6W	Service Designation†	
GL-5557	Thyratron	I	5751	Five-Star	F
GL-5558	Rectifier	I	5751WA	Service Designation†	
GL-5559	Thyratron	I	GL-5762	Triode	
GL-5560	Thyratron	I	5763	Beam Pentode	F
GL-5561	Rectifier	I	GL-5779	Ignitron	I
GL-5564	Ignitron	I	GL-5788	Ignitron	I
GL-5581	Phototube		5814-A	Five-Star	F
GL-5593	Phasitron		5814WA	Service Designation†	
5610	Triode	F	GL-5820	Image Orthicon	T
GL-5620	Ballast Tube		GL-5822-A	Ignitron	I
GL-5621	Ballast Tube		5824	Pentode	F
GL-5623	Ballast Tube		GL-5830	Thyratron	I
GL-5624	Ballast Tube		5840	Five-Star	F
GL-5625	Rectifier		5844	Twin Triode	F
GL-5626	Vacuum Switch		GL-5855	Thyratron	I
GL-5627	Vacuum Switch		5879	Pentode	F
GL-5628	Vacuum Gage		5881	Beam Pentode	F
GL-5629	Vacuum Gage		GL-5894	Tetrode	
GL-5630	Ignitron	I	5896	Five-Star	F
GL-5632/C3J	Thyratron		5899	Five-Star	F
5636	Five-Star	F	5902	Five-Star	F
5642	Diode	F	GL-5948	Thyratron	I
5651	Glow Tube	F	5963	Twin Triode	F
5654	Five-Star	F	5964	Twin Triode	F
5654/6AK5W	Service Designation†		5965	Twin Triode	F
5654/6AK5W/6096	Service Designation†		GL-5973	Rectifier	I
5662	Thyratron	F	6005	Five-Star	F
5663	Thyratron	F	6005/6AQ5W	Service Designation†	
GL-5665/C16J	Thyratron		6005/6AQ5W/6095	Service Designation†	
5670	Five-Star	F	GL-6011/710	Thyratron	I
5670WA	Service Designation†		GL-6014/C1K	Thyratron	
GL-5674	Pentode		GL-6019	Tetrode	T
5686	Five-Star	F	6021	Five-Star	F
5687	Twin Triode	F	GL-6039	Triode	T
5691	Twin Triode	F	GL-6044	Thyratron	
5692	Twin Triode	F	6046	Beam Pentode	F
5693	Pentode	F	6072	Five-Star	F
5696	Thyratron	F	6080	Twin Triode	
5718	Five-Star	F	6087	Five-Star	F
5719	Five-Star	F	6100/6C4WA	Service Designation†	
GL-5720	Thyratron	I	6111	Five-Star	F
5725	Five-Star	F	6112	Five-Star	F
5725/6AS6W	Service Designation†		6134	Five-Star	
5726	Five-Star	F	6135	Five-Star	
5726/6AL5W	Service Designation†		6136	Five-Star	F
5726/6AL5W/6097	Service Designation†		6137	Five-Star	
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† Because of the special nature of this type, data sheets are not maintained. Refer to the applicable Armed Service specifications for ratings.

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Tube Type	Class	Manual*	Tube Type	Class	Manual*
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GL-6198-A	Camera Tube	T	6663	Twin Diode	F
6201	Five-Star	F	6669	Beam Pentode	F
6202	Five-Star	F	6677	Pentode	F
6203	Five-Star	F	6678	Triode-Pentode	F
6205	Five-Star	F	6679	Twin Triode	F
6206	Pentode		6680	Twin Triode	F
6211	Twin Triode	F	6681	Twin Triode	F
GL-6228	Ignitron	I	GL-6787	Magnetron	
GL-6237	Klystron	T	GL-6807	Thyratron	I
GL-6238	Klystron	T	GL-6808	Thyratron	I
GL-6239	Klystron	T	GL-6809	Thyratron	I
GL-6240	Klystron	T	6829	Five-Star	F
GL-6241	Klystron	T	GL-6849	Image Orthicon	T
GL-6242	Klystron	T	GL-6855/716	Thyratron	
GL-6251	Tetrode	T	GL-6856/740	Thyratron	
6265	Five-Star	F	GL-6857/740-P	Thyratron	
GL-6283	Tetrode	T	GL-6858/760	Thyratron	
GL-6299	Triode	T	GL-6859/760-P	Thyratron	
GL-6301	Reference Cavity	T	GL-6860/C6J/F	Thyratron	
GL-6346	Ignitron	I	GL-6878	Ignitron	I
GL-6347	Ignitron	I	GL-6897	Triode	T
GL-6348	Ignitron	I	GL-6917	Magnetron	T
6350	Triode		6919	Twin Diode	F
6386	Five-Star	F	GL-6930/635-P	Rectifier	
6397	Power Pentode		GL-6942	Tetrode	T
GL-6410	Magnetron	T	GL-6958	Ignitron	I
6414	Five-Star	F	7036	Heptode	F
GL-6442	Triode	T	GL-7042	Ignitron	
GL-6452	Reference Cavity	T	7077	Triode	
6463	Twin Triode	F	GL-7085/356	Triode	T
6485	Pentode	F	GL-7151	Ignitron	
GL-6504	Ignitron	I	GL-7171	Ignitron	
GL-6509	Ignitron	I	GL-7179	Ignitron	
GL-6511	Ignitron	I	GL-7180	Ignitron	
GL-6512	Ignitron	I	GL-8000	Triode	
GL-6513	Ignitron	I	GL-8002	Triode	
GL-6514	Ignitron	I	GL-8002-R	Triode	
GL-6515	Ignitron	I	GL-8005	Triode	
6525	Thyratron	F	GL-8008	Rectifier	I
GL-6619	Gas-Discharge Device	T	GL-8013-A	Rectifier	
GL-6620	Gas-Discharge Device	T	GL-8020	Rectifier	
GL-6621	Gas-Discharge Device	T	9001	Pentode	F
GL-6625	Klystron	T	9002	Triode	F
6660	Pentode	F	9003	Pentode	F

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ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
Schenectady 5, N. Y.

PRINTED
IN
U.S.A.

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Supersedes ETX-101Y, dated 5-59

The tubes and arrangements disclosed herein may be covered by patents of General Electric Company or others. Neither the disclosure of any information herein nor the sale of tubes by General Electric Company conveys any license under patent claims covering combinations of tubes with other devices or elements. In the absence of an express written agreement to the contrary, General Electric Company assumes no liability for patent infringement arising out of any use of the tubes with other devices or elements by any purchaser of tubes or others.

ELECTRONIC COMPONENTS DIVISION

GENERAL  ELECTRIC

Schenectady 5, N. Y.

INTERCHANGEABILITY LIST

Transmitting Tubes

This listing includes those types for which the General Electric Company has either a direct replacement or a similar type comparable in capabilities and application.

TGRA—GL-4-250A/5D22

Type No.	Class	Manufacturer	Direct G-E Replacement Type	G-E Similar Type	Type No.	Class	Manufacturer	Direct G-E Replacement Type	G-E Similar Type
TGRA	R	IH	GL-575-A		GL-2H21	TR	GE	GL-2H21	
TGRB	R	IH	GL-872-A		2E24	TR	GE, HY, RCA, RK, S	GL-2E24	GL-2E24
TVTB	TR	IH	GL-833-A		2E25	TR	HY		
TVTC	TR	IH	GL-889-A		2E26	TR	GE, HY, RCA, RK, S	GL-2E26	
GL-1L21	TR	GE	GL-1L21		2E30	TR	GE, HY	GL-2E30	
					3-25A3	TR	EM		GL-809
GL-1L24	TR	GE	GL-1L24		3-50A4	TR	EM		GL-811-A
GL-1L25	TR	GE	GL-1L25		3-75A3	TR	EM		GL-8005
GL-1L31	TR	GE	GL-1L31		3-100A	TR	EM		GL-810
GL-1L32	TR	GE	GL-1L32		3-450A4	TR	EM		GL-833-A
GL-1L33	TR	GE	GL-1L33						
					3-1000A2	TR	EM		GL-8000
GL-1L36	TR	GE	GL-1L36		3-1000A4	TR	EM		GL-810
GL-1L38	TR	GE	GL-1L38		3B27	R	EE		GL-836
GL-1Q26-A	TR	GE	GL-1Q26-A		DR-3B27	R	GES		GL-836
GL-2B22	TR	GE	GL-2B22		3B28	R	CH, RCA, UE		GL-866-A
2C38	TR	EM		GL-2C39-B	AX-3B28	R	A	GL-866-A	
					3B28/6277	R	T	GL-866-A	
					3C21	TR	A		GL-838
2C39	TR	EM	GL-2C39-B		3X100A11	TR	EM	GL-2C39-B	
ML-2C39	TR	ML	GL-2C39-B		3X2500A3	TR	GE, EM	GL-3X2500A3	
2C39-A	TR	A, EM, RCA	GL-2C39-B		4-125A	TR	EM	GL-4D21/4-125A	
ML-2C39-A	TR	ML	GL-2C39-B		4-125A/4D21	TR	RCA	GL-4D21/4-125A	
2C39-B	TR	GE, EM	GL-2C39-B		AX-4-125A/6155	TR	A		GL-4D21/4-125A
					4-250A	TR	RCA	GL-4-250A/5D22	
2C40	TR	RCA	GL-2C40-A		GL-4-250A/5D22	TR	GE	GL-4-250A/5D22	
GL-2C40-A	TR	GE	GL-2C40-A						
GL-2C42	TR	GE	GL-2C42						
2C43	TR	GE, RCA	GL-2C43						
GL-2C46	TR	GE	GL-2C46						

MANUFACTURER'S IDENTIFICATION

A—AMPEREX ELECTRONIC CORPORATION
 CE—CONTINENTAL ELECTRIC COMPANY (CETRON)
 CH—CHATHAM ELECTRONICS
 EE—ELECTRONIC ENTERPRISES, INCORPORATED
 EL—ELECTRONS, INCORPORATED
 EM—EITEL-MCCULLOUGH, INCORPORATED (EIMAC)
 F—FEDERAL TELEPHONE AND RADIO COMPANY
 GE—GENERAL ELECTRIC COMPANY
 GES—GENERAL ELECTRONICS, INCORPORATED
 HK—HEINTZ AND KAUFMAN, LIMITED
 HY—CBS HYTRON

IH—INDUCTION HEATING CORPORATION
 ML—MACHLETT LABORATORIES, INCORPORATED
 NU—NATIONAL UNION ELECTRIC CORPORATION
 RCA—RADIO CORPORATION OF AMERICA
 RK—RAYTHEON MANUFACTURING COMPANY
 S—SYLVANIA ELECTRIC PRODUCTS, INCORPORATED
 T—TAYLOR TUBES, INCORPORATED
 TS—TUNG-SOL ELECTRIC, INCORPORATED
 UE—UNITED ELECTRONICS COMPANY
 WE—WESTERN ELECTRIC
 WL—WESTINGHOUSE ELECTRIC CORPORATION
 WT—WELTRONIC COMPANY

TUBE CLASSIFICATION

K—KLYSTRON
 M—MAGNETRON
 R—RECTIFIER
 TR—TRANSMITTING

GENERAL  ELECTRIC

Supersedes ET-T1218 dated 10-55

WL-4-250A/5D22—211H

INTERCHANGEABILITY LIST

Type No.	Class	Manufacturer	Direct G-E Replacement Type	G-E Similar Type	Type No.	Class	Manufacturer	Direct G-E Replacement Type	G-E Similar Type
WL-4-250A/5D22	TR	WL	GL-4-250A/5D22		RK-47	TR	RK	GL-814	
AX-4-250A/6156	TR	A		GL-4-250-A/5D22	RK-48A	TR	RK		GL-813
4-1000A	TR	GE, RCA, EM	GL-4-1000A		50T	TR	T		GL-8000
4C22	TR	A		GL-8005	HY-51B	TR	HY		GL-8005
4D21	TR	RK	GL-4D21/4-125A		51T	TR	T		GL-8005
GL-4D21/4-125A	TR	GE	GL-4D21/4-125A		HY-51Z	TR	HY		GL-838
WL-4D21/4-125A	TR	WL	GL-4D21/4-125A		RK-52	TR	RK		GL-811-A
4D23	TR	RK		GL-4D21/4-125A	T-55	TR	NU, T, UE	GL-805	GL-8005
4X150A	TR	GE, A, EM, RCA, WL	GL-4X150A		HY-57	TR	HY		GL-812-A
4X150G	TR	EM		GL-4X-150A	RK-57	TR	RK		
GL-5C24	TR	GE	GL-5C24		RK-58	TR	RK	GL-838	
5D22	TR	UE	GL-4-250A/5D22		HF-60	TR	A	GL-8005	
WL-5D22	TR	WL	GL-4-250A/5D22		HY-60	TR	HY		GL-807
5D24	TR	F		GL-4-250-A/5D22	T-60	TR	T	GL-807	GL-8005
7C24	TR	RCA	GL-5762		HY-61/807	TR	HY		
ML-7C24	TR	ML	GL-5762		RK-64	TR	RK		GL-807
F-7C25	TR	F		GL-5762	HY-69	TR	HY		GL-1624
F-7C27	TR	F		GL-5762	V-70D	TR	NU, UE		GL-8005
GL-7C29	TR	GE	GL-7C29		75TH	TR	EM		GL-8005
F-7C30	TR	F		GL-5762	HF-100	TR	A		GL-8005
GL-7D21	TR	GE	GL-7D21		UE-100	TR	UE	GL-8020	GL-810
RK-12	TR	RK		GL-809	100R	R	EM	GL-100TH	
HY-18	TR	UE		GL-810	100TH	TR	GE, EM, NU		GL-8000
FV-20	TR	UE		GL-8000	100TL	TR	EM		GL-812-A
TV-20	TR	T		GL-810	111H	TR	A		GL-8005
TZ-20	TR	T		GL-809	HF-120	TR	A		GL-838
RK-21	R	RK		GL-836	ZB-120	TR	A		GL-8005
RX-21A	R	EM		GL-872-A	HF-125	TR	A		GL-810
WE-X-22	R	UE		GL-1616	T-125	TR	T		GL-810
KU-23	TR	NU		GL-810	F-127-A	TR	F		
RK-23	TR	RK		GL-802	WT-T127*†	TR	WT	See WT-210-0086	GL-851
RK-23A	TR	RK		GL-802	F-128-A	TR	F		GL-889-A
HY-25	TR	HY		GL-809	F-129-B	TR	F		GL-8005
RK-25	TR	RK	GL-802		HF-140	TR	A		GL-807,
RK-25B	TR	RK	GL-802		TW-150	TR	T		GL-810
25T	TR	EM		GL-809	ML-199	R	ML		GL-5973
RK-28	TR	RK	GL-803		HF-200	TR	A, ML		GL-8000
RK-28-A	TR	RK	GL-803		HF-201	TR	A		GL-8000
HY-30Z	TR	HY		GL-809	HF-201A	TR	A		GL-810
NU-30Z	TR	NU		GL-809	203-A	TR	A, NU, RCA, T, UE		GL-8005
35T	TR	EM		GL-811-A	WL-203-A	TR	WL		GL-8005
RK-38	TR	RK		GL-810	203-Z	TR	T	GL-207	GL-838
RK-39	TR	RK		GL-812-A	207	TR	GE, A, F, RCA	GL-207	
HY-40	TR	HY	GL-807		ML-207	TR	ML	GL-207	
T-40	TR	T		GL-812-A	UE-207	TR	UE		
TZ-40	TR	T		GL-811-A	WL-207	TR	WL	GL-207	
HY-40Z	TR	HY		GL-811-A	WT-210-0008†	R	WT	GL-866-A	
RK-41	TR	RK		GL-807	WT-210-0027†	R	WT	GL-872-A	
RK-44	TR	RK	GL-837		WT-210-0086†	TR	WT	GL-833-A	
RK-45	TR	RK		GL-837	211	TR	A, NU, RCA, T		GL-8005
					UE-211	TR	UE		GL-8005
					WL-211	TR	WL		GL-8005
					211B	TR	A		GL-8005
					211D	TR	A, WE		GL-8005
					211H	TR	A		GL-8005

* Old part number. Refer to Weltronic's new part number for GE equivalent.

† These are tube socket markings on equipment bearing the Weltronic trademark.

INTERCHANGEABILITY LIST

CE-220—DR-801-A

Type No.	Class	Manufacturer	Direct G-E Replacement Type	G-E Similar Type	Type No.	Class	Manufacturer	Direct G-E Replacement Type	G-E Similar Type
CE-220	R	CE		GL-8020	319A	R	WE		GL-872-A
HF-220R	TR	A		GL-893A-R	F-319A	R	F		GL-872-A
Z-225/866A	R	NU, UE		GL-866-A	ML-319A	R	ML		GL-872-A
233	TR	A		GL-880	321A	R	WE		GL-673
241B	TR	WE		GL-833-A	HF-321A	R	A		GL-673
242A	TR	WE		GL-8005	ML-321A	R	ML		GL-673
242B	TR	WE		GL-8005	322A	TR	WE	GL-803	
242C	TR	GE, A, UE, WE	GL-242-C		327A	TR	WE		GL-810
ML-242-C	TR	ML	GL-242-C		327B	TR	WE		GL-810
249A	R	WE		GL-866-A	331A	TR	WE	GL-805	
249B	R	T, WE		GL-866-A	332A	TR	WE		GL-803
WE-249C	R	WE		GL-866-A	QK-338	M	RK	GL-6410	
HF-250	TR	A		GL-8000	339A	TR	WE		GL-807
250TH	TR	EM		GL-810	UE-342B	TR	UE		GL-8005
DR-250TH	TR	GES		GL-810	342-C	TR	UE	GL-242-C	
251A	TR	A, WE		GL-851	348A	TR	WE		GL-1620
HF-251A	TR	A		GL-851	350A	TR	WE	GL-807	
HK-254	TR	HK		GL-810	350B	TR	WE		GL-807
255A	R	WE		GL-869-B	F-353A	R	F	GL-872-A	
255B	R	WE		GL-869-B	HK-354F	TR	HK		GL-8005
HF-255B	R	A		GL-869-B	356A	TR	WE		GL-807
258B	R	A, T, UE		GL-866-A	357A	TR	WE		GL-833-A
WT-262*†	R	WT	See WT-210-0008		357B	TR	ML		GL-833-A
FP-265	TR	GE	FP-265		F-357-B	R	F	GL-857-B	
F-266-A	R	F	GL-266-B		366A	R	WE	GL-866-A	
266B	R	WE		GL-857-B	F-367-A	R	F		GL-673
F-266B	R	F		GL-857-B	371-B	R	EE, UE		GL-8020
HF-266-B	R	A	GL-266-B		F-375A	R	F	GL-575-A	
266C	R	WE		GL-857-B	ML-381	TR	ML	GL-2C39-B	
267B	R	WE		GL-872-A	384D	TR	WE		GL-845
F-267B	R	F		GL-872-A	UE-384D	TR	UE		GL-845
HF-267B	R	A		GL-872-A	WL-450	TR	WL		GL-833-A
268A	TR	WE		GL-801-A	450TH	TR	EM		GL-833-A
279A	TR	WE		GL-851	F-450TH	TR	F		GL-833-A
HF-279A	TR	A		GL-851	UE-468	TR	UE		GL-810, GL-8000
T-282A	TR	T		GL-8000	WL-468	TR	WL		GL-810
284A	TR	WE		GL-845	WL-471	TR	WL		GL-8005, GL-8003
284B	TR	WE		GL-845					
284D	TR	UE, WE		GL-845	WL-473	TR	WL		GL-5762
295A	TR	WE		GL-8005	WL-481	R	WL		GL-8013-A
					559	TR	RCA		GL-2B22
298A	TR	WE		GL-862-A	575-A	R	GE, A, EE, NU, RCA	GL-575-A	
ML-298-A	TR	ML		GL-862-A	DR-575-A	R	GES	GL-575-A	
298B	TR	WE		GL-862-A	F-575-A	R	F	GL-575-A	
T-303C	TR	T		GL-8000	ML-575-A	R	ML	GL-575-A	
UE-303U	TR	UE		GL-8000	WL-575-A	R	WL	GL-575-A	
307A	TR	WE		GL-807	UE-578	R	UE		GL-8020
F-307A	TR	F	GL-207		WL-578	R	WL		GL-8020
310	TR	UE		GL-801-A	GL-592	TR	GE	GL-592	
310B	TR	WE		GL-1620	592/3-200A3	TR	EL, EM	GL-592	
UE-311	TR	UE		GL-8005	673	R	GE, A, F, RCA	GL-673	
UE-311CH	TR	UE		GL-8000	ML-673	R	ML	GL-673	
312A	TR	WE		GL-828	T-756	TR	T		GL-809
315A	R	A, WE		GL-673	801	TR	RCA	GL-801-A	
F-315A	R	F		GL-673	801A	TR	GE, A, NU, RCA	GL-801-A	
ML-315A	R	ML		GL-673	DR-801-A	TR	GES	GL-801-A	

* Old part number. Refer to Weltronic's new part number for G-E equivalent.

† These are tube socket markings on equipment bearing the Weltronic trademark.

WL-801-A—862-A

INTERCHANGEABILITY LIST

Type No.	Class	Manufacturer	Direct G-E Replacement Type	G-E Similar Type	Type No.	Class	Manufacturer	Direct G-E Replacement Type	G-E Similar Type
WL-801-A HY-801-A 801-A/801 802 WL-802	TR TR TR TR TR	WL HY HY, S GE, A, NU, RCA WL	GL-801-A GL-801-A GL-801-A GL-802 GL-802		WL-816 828 ML-828 WL-828 829	R TR TR TR TR	WL GE, A, NU, RCA ML WL RCA	GL-816 GL-828 GL-828 GL-828 GL-829-B	
803 DR-803 T-803 WL-803 805	TR TR TR TR TR	GE, A, NU, RCA GES T WL GE, A, NU, RCA	GL-803 GL-803 GL-803 GL-803 GL-805		829-A 829-B ML-829-B RK-829-B WL-829B	TR TR TR TR TR	RCA GE, A, NU, RCA, S, T ML RK WL	GL-829-B GL-829-B GL-829-B GL-829-B GL-829-B	
DR-805 ML-805 T-805 UE-805 WL-805	TR TR TR TR TR	GES ML T UE WL	GL-805 GL-805 GL-805 GL-805 GL-805		832 832-A DR-832-A ML-832-A RK-832-A	TR TR TR TR TR	RCA GE, A, NU, RCA, S, T GES ML RK	GL-832-A GL-832-A GL-832-A GL-832-A GL-832-A	
807 DR-807 WL-807 809 DR-809	TR TR TR TR TR	GE, A, HY, NU, RK, RCA, S, TS GES WL GE, NU, RCA, S GES	GL-807 GL-807 GL-807 GL-809 GL-809		WL-832-A 833 833-A DR-833-A ML-833-A	TR TR TR TR TR	WL RCA GE, A, RCA GES ML	GL-832-A GL-833-A GL-833-A GL-833-A GL-833-A	
WL-809 810 DR-810 ML-810 T810	TR TR TR TR TR	WL GE, A, NU, RCA, S GES ML T	GL-809 GL-810 GL-810 GL-810 GL-810		UE-833-A WL-833-A 836 DR-836 EE-836	TR TR R R R	UE WL A, NU, RCA GES EE	GL-833-A GL-833-A GL-836 GL-836 GL-836	
UE-810 WL-810 811 DR-811 NU-811	TR TR TR TR TR	UE WL A, NU, RCA, S GES NU	GL-810 GL-810 GL-811-A GL-811-A GL-811-A		WL-836 837 DR-837 WL-837 RK-837	R TR TR TR TR	WL GE, A, HY, NU, RCA, S GES WL RK	GL-836 GL-837 GL-837 GL-837 GL-837	
WL-811 811-A WL-811-A 812 DR-812	TR TR TR TR TR	WL GE, RCA, RK, S WL A, NU, RCA, S GES	GL-811-A GL-811-A GL-811-A GL-812-A GL-812-A		838 DR-838 T-838 UE-838 WL-838	TR TR TR TR TR	GE, A, NU, RCA GES T UE WL	GL-838 GL-838 GL-838 GL-838 GL-838	
NU-812 WL-812 812-A WL-812-A UE-812-H	TR TR TR TR TR	NU WL GE, S, RCA, RK WL UE	GL-812-A GL-812-A GL-812-A GL-812-A GL-812-A	GL-8005	845 T-845 UE-845 WL-845 849A	TR TR TR TR TR	GE, A, NU, RCA T UE WL A	GL-845 GL-845 GL-845 GL-845 GL-845	GL-833-A
813 DR-813 ML-813 RK-813 T-813	TR TR TR TR TR	GE, A, NU, RCA, S GES ML RK T	GL-813 GL-813 GL-813 GL-813 GL-813		849H 851 DR-851 UE-851 WL-851	TR TR TR TR TR	A GE, A, RCA GES UE WL	GL-851 GL-851 GL-851 GL-851 GL-851	GL-833-A
UE-813 WL-813 814 T-814 WL-814	TR TR TR TR TR	UE WL GE, NU, RCA T WL	GL-813 GL-813 GL-814 GL-814 GL-814		HK-854H 857 857-B DR-857-B F-857-B	TR R R R R	HK RCA GE, A, RCA GES F	GL-857-B GL-857-B GL-857-B GL-857-B GL-857-B	GL-833-A
RK-814/RK47 815 WL-815 816 DR-816	TR TR TR R R	RK GE, NU, S, RCA WL GE, A, HY, NU, RCA, RK, S GES	GL-814 GL-815 GL-815 GL-816 GL-816		ML-857-B WL-857-B 859 862 862-A	R R TR TR TR	ML WL A RCA GE, RCA	GL-857-B GL-857-B GL-862-A GL-862-A	GL-893-A

INTERCHANGEABILITY LIST

F-862-A—ML-5894

Type No.	Class	Manufacturer	Direct G-E Replacement Type	G-E Similar Type	Type No.	Class	Manufacturer	Direct G-E Replacement Type	G-E Similar Type
F-862-A	TR	F	GL-862-A		898-A	TR	GE, A, RCA	GL-898-A	
WL-862-A	TR	WL	GL-862-A		F-898-A	TR	F	GL-898-A	
866	R	A, RCA	GL-866-A		UE-905	TR	UE	GL-805	
866-A	R	GE, CE, CH, EM, NU, RCA, S	GL-866-A		UE-938	TR	UE	GL-838	
DR-866-A	R	GES	GL-866-A		UE-945	TR	UE	GL-845	
EE-866-A	R	EE	GL-866-A		951	TR	UE	GL-851	
HF-866-A	R	A	GL-866-A		UE-966	R	UE	GL-866-A	
ML-866-A	R	ML	GL-866-A		UE-966-A	R	UE	GL-866-A	
RK-866-A	R	RK	GL-866-A		UE-972	R	UE	GL-872-A	
T-866-A	R	T	GL-866-A		UE-972-A	R	UE	GL-872-A	
UE-866-A	R	UE	GL-866-A		975-A	R	NU	GL-575-A	
WL-866-A	R	WL	GL-866-A		UE-975-A	R	UE		GL-575-A
866-A/866	R	RCA	GL-866-A		1000T	TR	GE, EM	GL-1000T	
866-AX	R	A		GL-866-A	WL-1000T	TR	WL	GL-1000T	
866-JR	R	NU, T		GL-866-A	1603	TR	TS		GL-1620
869-A	R	RCA	GL-869-B		1612	TR	GE, RCA	GL-1612	
869-B	R	GE, A, RCA	GL-869-B		1613	TR	GE, RCA	GL-1613	
DR-869-B	R	GES	GL-869-B		1614	TR	GE, RCA	GL-1614	
F-869-B	R	F	GL-869-B		1616	R	GE, A, HY, NU, RCA, S	GL-1616	
ML-869-B	R	ML	GL-869-B		DR-1616	R	GES	GL-1616	
WL-869-B	R	WL	GL-869-B		1619	TR	GE, NU, RCA	GL-1619	
870	R	RCA	GL-870-A		1620	TR	GE, NU, RCA	GL-1620	
GL-870-A	R	GE	GL-870-A		1621	TR	GE, NU, RCA	GL-1621	
872	R	RCA	GL-872-A		1624	TR	GE, NU, RCA	GL-1624	
872-A	R	GE, CE, EM, NU, RCA, S, T	GL-872-A		1625	TR	GE, A, HY, NU, RCA, S, TS	GL-1625	
DR-872-A	R	GES	GL-872-A		DR-1625	TR	GES	GL-1625	
EE-872-A	R	EE	GL-872-A		RK-1625	TR	RK	GL-1625	
F-872-A	R	F	GL-872-A		GL-5513	TR	GE	GL-5513	
RK-872-A	R	RK	GL-872-A		5514	TR	HY		GL-811-A
UE-872-A	R	UE	GL-872-A		5516	TR	GE, HY	GL-5516	
872-A/872	R	RCA	GL-872-A		GL-5518	TR	GE	GL-5518	
ML-872-A/872	R	ML	GL-872-A		ML-5530	TR	ML		GL-5762
WL-872-A/872	R	WL	GL-872-A		5588	TR	GE, RCA	GL-5588	
872-AX	R	A	GL-872-A		ML-5588	TR	ML	GL-5588	
T-875-A	R	T	GL-575-A		GL-5593	TR	GE	GL-5593	
880	TR	GE, A, RCA	GL-880		5604	TR	F		GL-889R-A
ML-880	TR	ML	GL-880		5618	TR	RCA	GL-2E30	
UE-880	TR	UE	GL-880		5658	TR	A, F	GL-880	
WL-880	TR	WL	GL-880		ML-5658	TR	ML	GL-880	
889	TR	RCA	GL-889-A		5666	TR	A, F	GL-889-A	
889-A	TR	GE, A, RCA	GL-889-A		ML-5666	TR	ML		GL-889-A
F-889-A	TR	F	GL-889-A		5667	TR	A	GL-889R-A	
ML-889-A	TR	ML	GL-889-A		F-5667	TR	F	GL-889R-A	
UE-889-A	TR	UE	GL-889-A		ML-5667	TR	ML	GL-889R-A	
WL-889-A	TR	WL	GL-889-A		EE-5695	R	EE	GL-816	
889R	TR	RCA	GL-889R-A		GL-5736	TR	GE	GL-5736	
889R-A	TR	GE, A, RCA	GL-889R-A		WL-5736	TR	WL	GL-5736	
F-889R-A	TR	F	GL-889R-A		ML-5736	TR	ML	GL-5736	
ML-889R-A	TR	ML	GL-889R-A		5762	TR	GE, RCA	GL-5762	
UE-889R-A	TR	UE	GL-889R-A		5762/7C24	TR	RCA	GL-5762	
WL-889R-A	TR	WL	GL-889R-A		5763	TR	GE, HY, RCA, S	GL-5763	
893A-R	TR	GE, A, RCA	GL-893A-R		5812	TR	HY		GL-5763
F-893A-R	TR	F	GL-893A-R		5868/AX9902	TR	A		GL-833-A
ML-893A-R	TR	ML	GL-893A-R		5894	TR	GE, A, RCA	GL-5894	
WL-893A-R	TR	WL	GL-893A-R		ML-5894	TR	ML	GL-5894	

5917—AX-9903

INTERCHANGEABILITY LIST

Type No.	Class	Manufacturer	Direct G-E Replacement Type	G-E Similar Type	Type No.	Class	Manufacturer	Direct G-E Replacement Type	G-E Similar Type
5917	TR	F		GL-5762	GL-6620	TR	GE	GL-6620	
5933	TR	S		GL-807	GL-6621	TR	GE	GL-6621	
5933-WA	TR	S		GL-807	GL-6625	K	GE	GL-6625	
GL-5973	R	GE	GL-5973		GL-6897	TR	GE	GL-6897	
GL-6019	TR	GE	GL-6019		7034/4X150A	TR	RCA	GL-4X150A	
GL-6039	TR	GE	GL-6039						
GL-6046	TR	GE	GL-6046		8000	TR	GE, RCA, T	GL-8000	
6146	TR	GE, RCA, S	GL-6146		ML-8000	TR	ML	GL-8000	
6155	TR	A		GL-4D21/ 4-125A	WL-8000	TR	WL	GL-8000	
				GL-4-250- A/5D22	8002	TR	GE, A	GL-8002	
6156	TR	A			8002-R	TR	GE, A	GL-8002-R	
6181	TR	GE, RCA	GL-6181		8005	TR	GE, A, NU, RCA	GL-8005	
GL-6182	TR	GE	GL-6182		ML-8005	TR	ML	GL-8005	
GL-6237	K	GE	GL-6237		WL-8005	TR	WL	GL-8005	
GL-6238	K	GE	GL-6238		8008	R	GE, A, CH, RCA, T	GL-8008	
GL-6239	K	GE	GL-6239		DR-8008	R	GES	GL-8008	
GL-6240	K	GE	GL-6240		EE-8008	R	EE	GL-8008	
GL-6241	K	GE	GL-6241		ML-8008	R	ML	GL-8008	
GL-6242	K	GE	GL-6242		UE-8008	R	UE	GL-8008	
GL-6251	TR	GE	GL-6251		WL-8008	R	WL	GL-8008	
ML-6258	TR	ML		GL-5518	8013	R	A	GL-8013-A	
6277/3B28A	R	T	GL-866-A						
GL-6283	TR	GE	GL-6283		8013-A	TR	GE, RCA	GL-8013-A	
GL-6299	TR	GE	GL-6299		8020	R	GE, A, NU, RCA	GL-8020	
GL-6301	TR	GE	GL-6301		DR-8020	R	GES	GL-8020	
6335	TR	ML		GL-6251	EE-8020	R	EE	GL-8020	
6410	M	GE, RK	GL-6410		WL-8020	R	WL	GL-8020	
6410/QK-338	M	RK	GL-6410						
GL-6442	TR	GE	GL-6442		8020/100R	R	EM	GL-8020	
GL-6452	TR	GE	GL-6452		AX-9903	TR	A	GL-5894	
GL-6619	TR	GE	GL-6619						

MANUFACTURER'S IDENTIFICATION

A—AMPEREX ELECTRONIC CORPORATION
 CE—CONTINENTAL ELECTRIC COMPANY (CETRON)
 CH—CHATHAM ELECTRONICS
 EE—ELECTRONIC ENTERPRISES, INCORPORATED
 EL—ELECTRONS, INCORPORATED
 EM—EITEL-McCULLOUGH, INCORPORATED (EIMAC)
 F—FEDERAL TELEPHONE AND RADIO COMPANY
 GE—GENERAL ELECTRIC COMPANY
 GES—GENERAL ELECTRONICS, INCORPORATED
 HK—HEINTZ AND KAUFMAN, LIMITED
 HY—CBS HYTRON

IH—INDUCTION HEATING CORPORATION
 ML—MACHLETT LABORATORIES, INCORPORATED
 NU—NATIONAL UNION ELECTRIC CORPORATION
 RCA—RADIO CORPORATION OF AMERICA
 RK—RAYTHEON MANUFACTURING COMPANY
 S—SYLVANIA ELECTRIC PRODUCTS, INCORPORATED
 T—TAYLOR TUBES, INCORPORATED
 TS—TUNG-SOL ELECTRIC, INCORPORATED
 UE—UNITED ELECTRONICS COMPANY
 WE—WESTERN ELECTRIC
 WL—WESTINGHOUSE ELECTRIC CORPORATION
 WT—WELTRONIC COMPANY

TUBE CLASSIFICATION

K—KLYSTRON
 M—MAGNETRON
 R—RECTIFIER
 TR—TRANSMITTING

This information has been carefully compiled from tube data available at the date of publication and is believed to be accurate. No responsibility, however, is assumed for errors caused by inaccuracies in tube data.

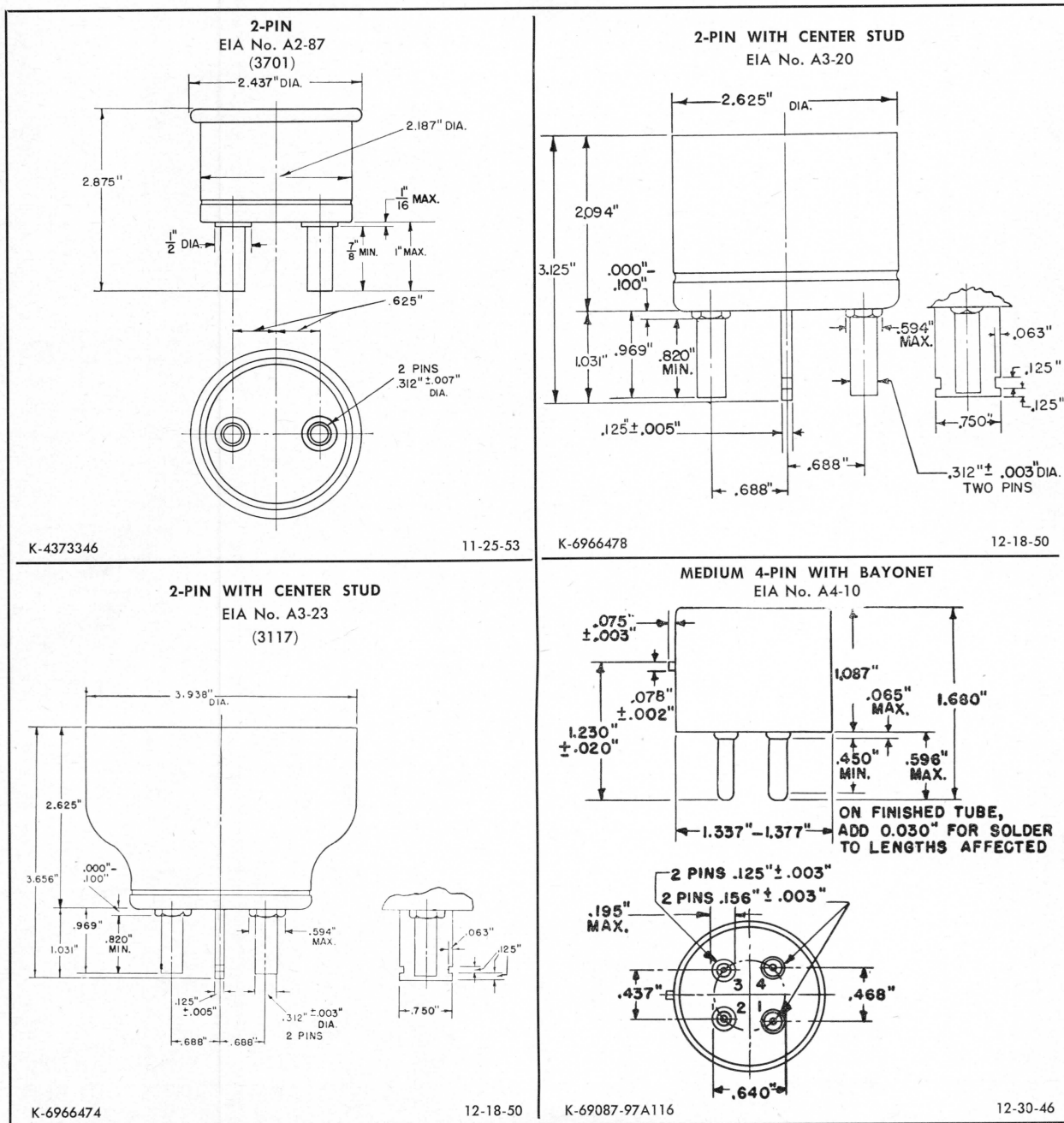
ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
 Schenectady 5, N. Y.

BASES, CAPS POWER TUBES

This listing includes the bases and caps used on all tubes included in the Industrial and Transmitting Tube Manuals. The bases are arranged in order by number of contacts. Following these, the caps are arranged by size.

The number references are the standard Electronic Industries Association numbers. These numbers are referenced on the tube outline drawings included with the technical data, enabling ready reference to the detailed drawings included here. In a few instances, the outline drawings on the data sheets have not been changed to show the EIA designation. In these cases the old General Electric identification is included in paranthesis with the EIA number.

BASES

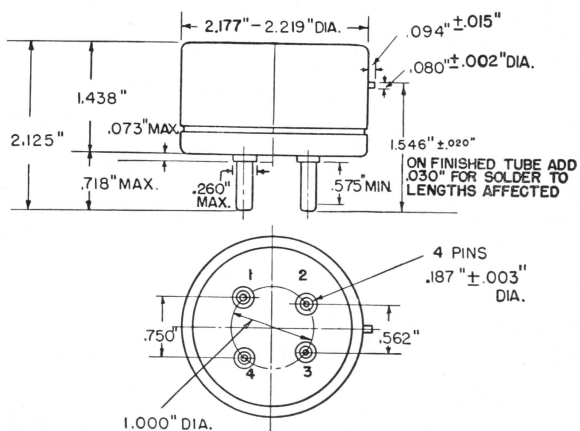


GENERAL ELECTRIC

Supersedes ETI-201B dated 12-50 and ETX-209A dated 3-51

BASES

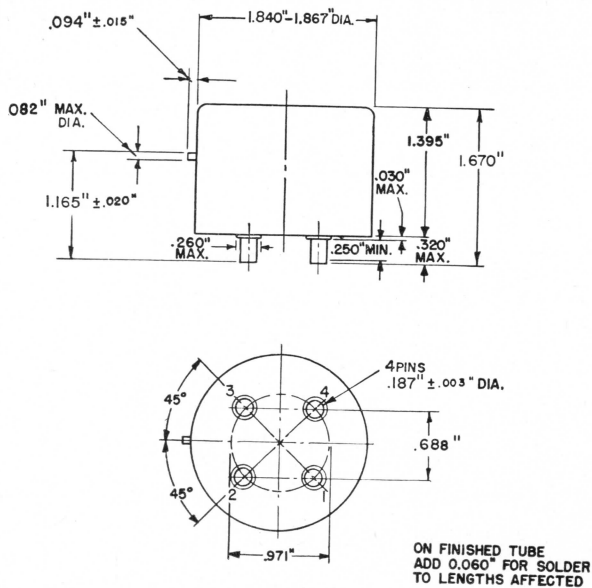
SUPER-JUMBO 4-PIN WITH BAYONET
EIA No. A4-18
(4310)



K-4955974

9-15-50

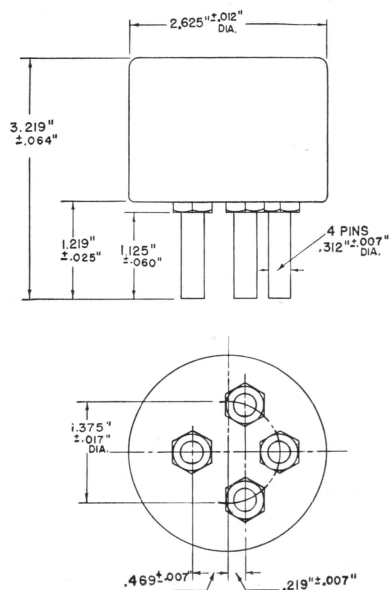
JUMBO 4-PIN WITH BAYONET
EIA No. A4-29



K-6966492

12-18-50

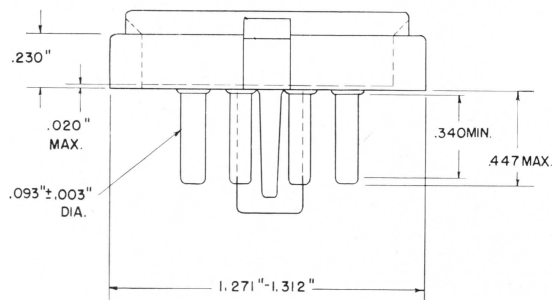
4-PIN
EIA No. A4-75



K-3846066

6-24-48

SMALL H-WAFER OCTAL, 6-PIN
EIA No. B6-108

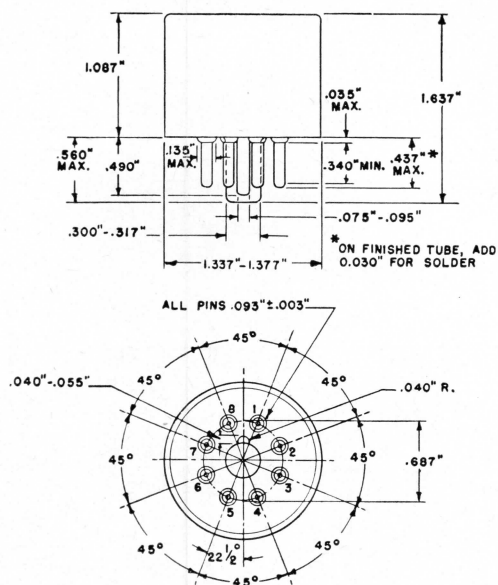


K-69087-97A189

10-9-58

BASES

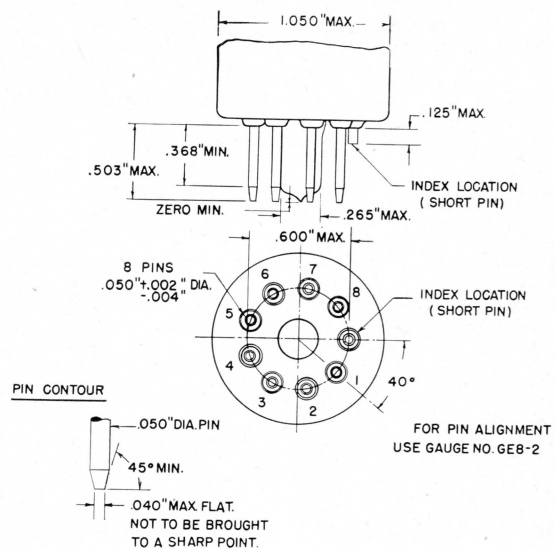
MEDIUM-SHELL OCTAL, 7-PIN
EIA No. B7-12



K-69087-97A126

12-30-46

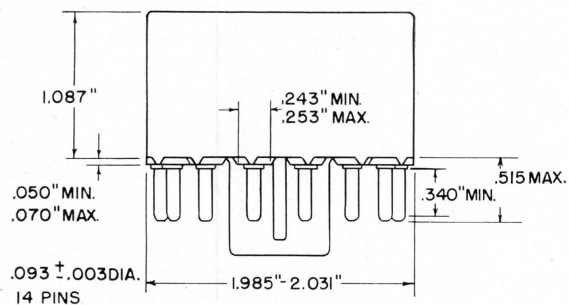
SMALL-BUTTON DITETRAR, 8-PIN
EIA No. E8-11



K-69087-97A187

10-8-58

SMALL-SHELL DIHEPTAL, 14-PIN
EIA No. B14-45



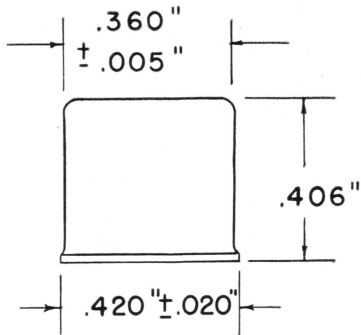
K-69087-97A188

10-8-58

CAPS

SMALL CAP

EIA No. C1-1

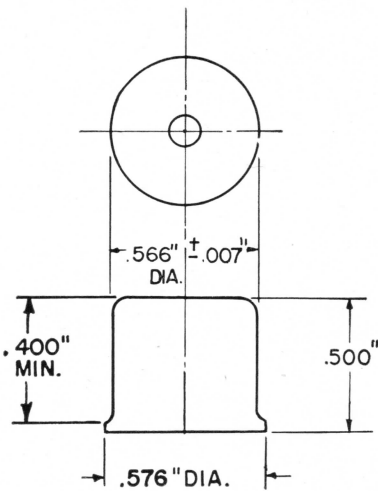


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MEDIUM CAP

EIA No. C1-5

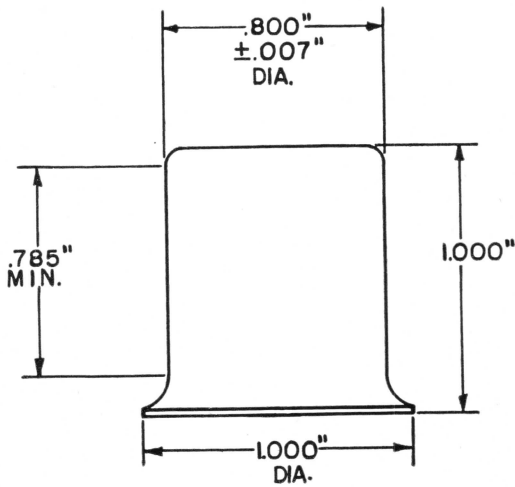


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LARGE CAP

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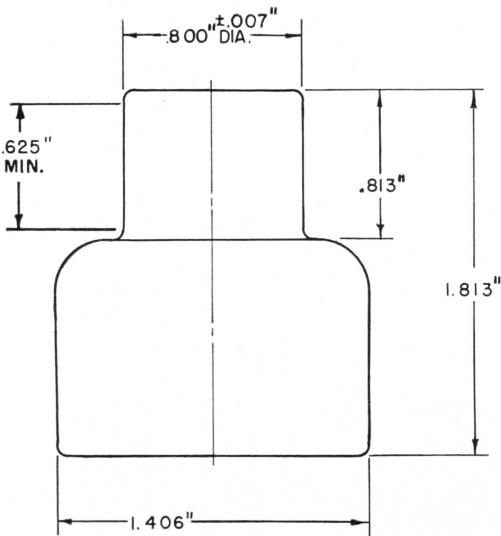


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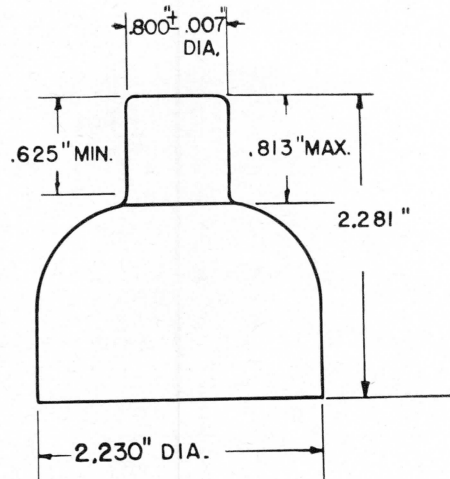


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CAPS

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(1904)

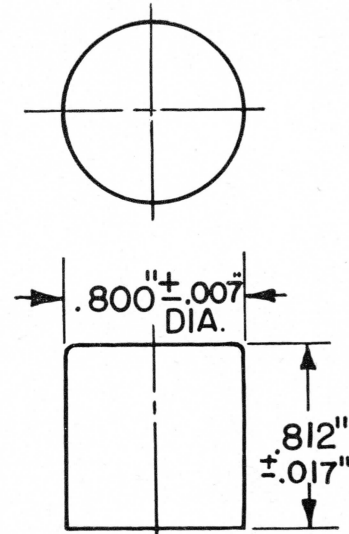


ON FINISHED TUBE ADD
0.060" FOR SOLDER TO
LENGTHS AFFECTED

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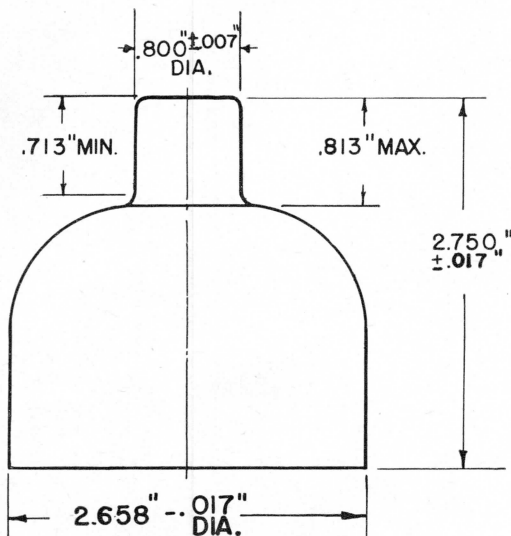
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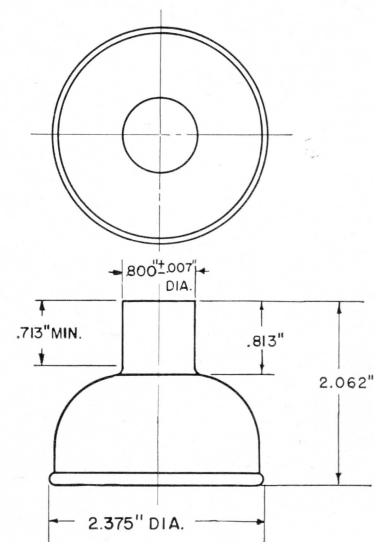
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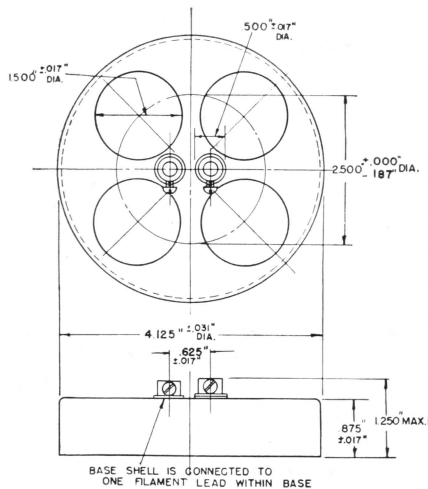
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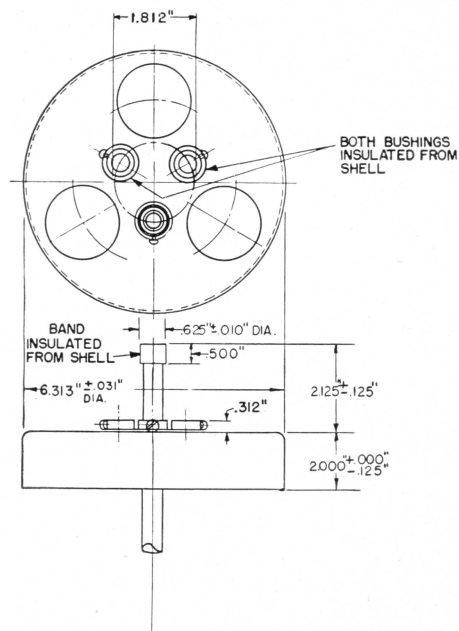
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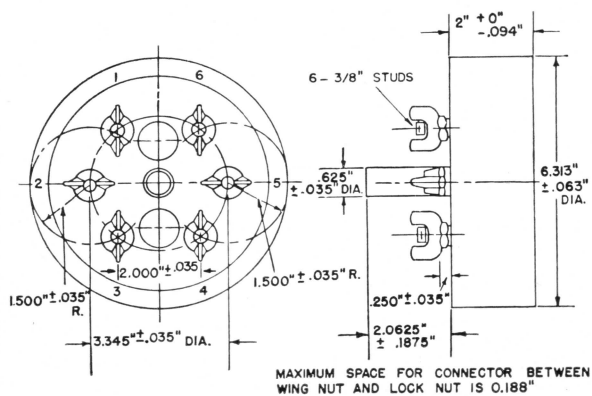
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EIA No. FO-3
(3908)



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TERMINAL-SUPPORT SHELL
EIA No. FO-6
(6628)



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ELECTRONIC COMPONENTS DIVISION

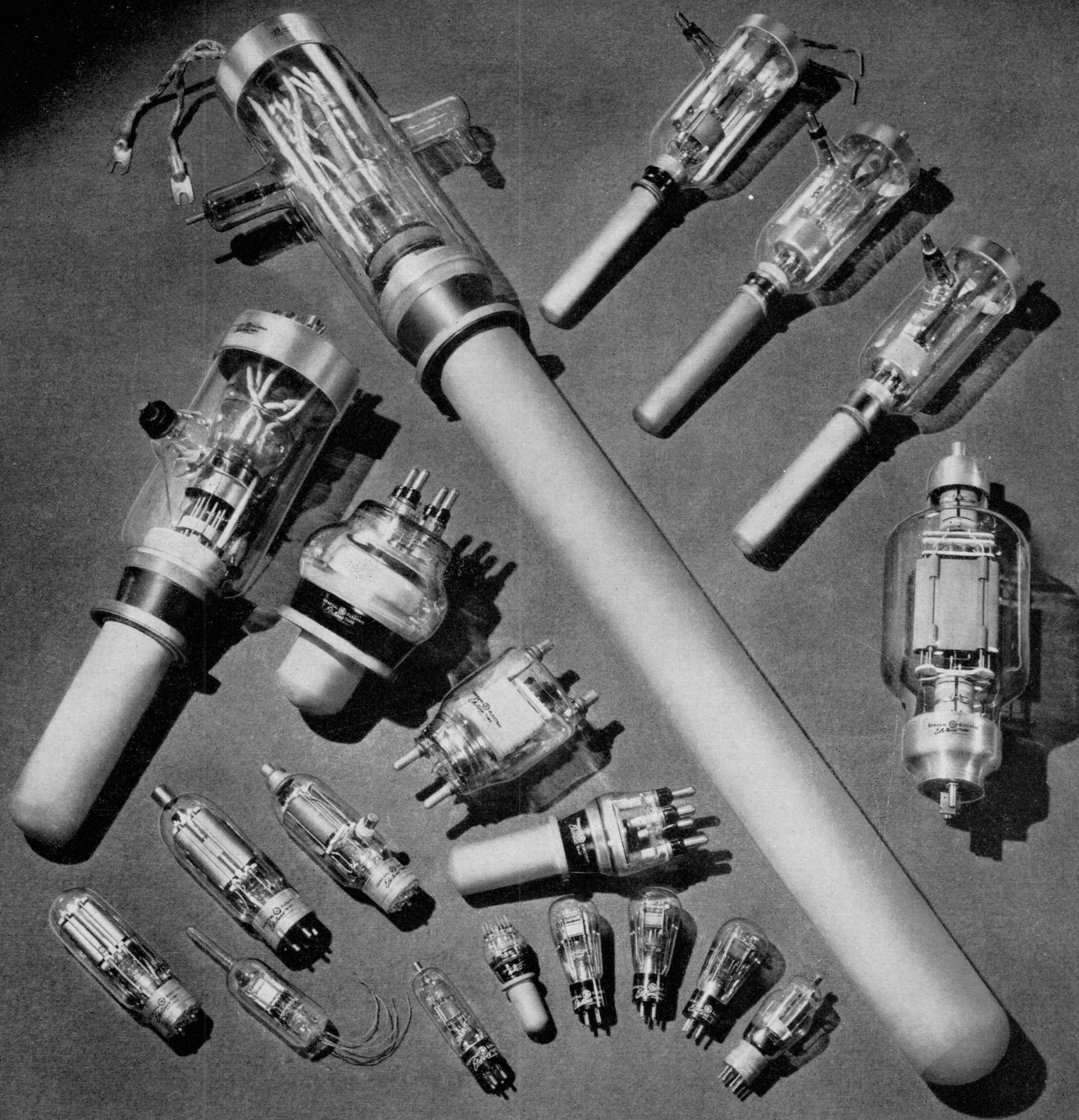
GENERAL ELECTRIC

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TRANSMITTING TUBES



DESCRIPTION

The term "transmitting tubes" is broad in implication. Power output ratings for example, range from a few watts to many kilowatts and tube lengths from three inches to more than five feet. No exact line of demarcation exists between transmitting and receiving tubes either in function or in name. The technical and application data contained in this manual deals primarily with tubes normally found in transmitters and associated equipment.

One of the most significant methods of classify-

ing transmitting tubes is by the system of cooling used. The three main classes are convection, forced-air, and water cooling, each roughly related to power output rating and physical size. Other systems of division are by the number and nature of the electrodes involved, by frequency range, or by common application. Since no single breakdown is all inclusive, technical information sheets are arranged by type number, and correlation charts and tables supplied in the "Quick Selection Chart"; ETX-104.

DEFINITIONS

The following definitions of terms which appear in this manual have been obtained from the IRE Standards for 1938. The key number refers to the identification number appearing in the Standards.

- 1E17. Cathode. A cathode is an electrode which is the primary source of an electron stream.
- 1E18. Filament. A filament is a cathode of a thermionic tube, usually in the form of a wire or ribbon, to which heat may be supplied by passing current through it.
- 1E19. Indirectly Heated Cathode. (Equipotential Cathode, Unipotential Cathode.) An indirectly heated cathode is a cathode of a thermionic tube to which heat is supplied by an independent heater element.
- 1E20. Heater. A heater is an electric heating element for supplying heat to an indirectly heated cathode.
- 1E21. Control Electrode. A control electrode is an electrode on which a voltage is impressed to vary the current flowing between two or more other electrodes.
- 1E22. Grid. A grid is an electrode having one or more openings for the passage of electrons or ions.
- 1E23. Space-Charge Grid. A space-charge grid is a grid which is placed adjacent to the cathode and positively biased so as to reduce the limiting effect of space charge on the current through the tube.
- 1E24. Control Grid. A control grid is a grid, ordinarily placed between the cathode and an anode, for use as a control electrode.
- 1E25. Screen Grid. A screen grid is a grid placed between a control grid and an anode, and usually maintained at a fixed positive potential, for the purpose of reducing the electrostatic influence of the anode in the space between the screen grid and the cathode.
- 1E26. Suppressor Grid. A suppressor grid is a grid which is interposed between two electrodes (usually the screen grid and

plate), both positive with respect to the cathode, in order to prevent the passing of secondary electrons from one to the other.

- 1E27. Anode. An anode is an electrode to which a principal electron stream flows.
- 1E28. Plate. Plate is a common name for the principal anode in a vacuum tube.
- 1E29. Electron Emission. Electron emission is the liberation of electrons from an electrode into the surrounding space. Quantitatively, it is the rate at which electrons are emitted from an electrode.
- 1E30. Thermionic Emission. Thermionic emission is electron or ion emission due directly to the temperature of the emitter.
- 1E31. Secondary Emission. Secondary emission is electron emission due directly to impact by electrons or ions.
- 1E32. Grid Emission. Grid emission is electron or ion emission from a grid.
- 1E33. Emission Characteristic. An emission characteristic is a relation, usually shown by a graph, between the emission and a factor controlling the emission (as temperature, voltage, or current of the filament or heater).
- 1E34. Cathode Current. Cathode current is the total current passing to or from the cathode through the vacuous space.
- 1E35. Filament Current. Filament current is the current supplied to a filament to heat it.
- 1E36. Filament Voltage. Filament voltage is the voltage between the terminals of a heater.
- 1E37. Heater Current. Heater current is the current flowing through a heater.
- 1E38. Heater Voltage. Heater voltage is the voltage between the terminals of a heater.
- 1E39. Electrode Current. Electrode current is the current passing to or from an electrode through the vacuous space. The terms grid current, anode current, plate current, etc., are used to designate currents passing to or from these specific electrodes.

- 1E40. **Electrode Voltage.** Electrode voltage is the voltage between an electrode and a specified point of the cathode. The terms grid voltage, anode voltage, plate voltage, etc., are used to designate the voltage between these specific electrodes and the cathode.
- 1E41. **Direct Grid Bias.** Direct grid bias is the direct component of grid voltage. This is commonly called grid bias.
- 1E42. **Grid Driving Power.** Grid driving power is the average product of the instantaneous value of the grid current and of the alternating component of the grid voltage over a complete cycle. This comprises the power supplied to the biasing device and to the grid.
- 1E43. **Peak Forward Anode Voltage.** Peak forward anode voltage is the maximum instantaneous anode voltage in the direction in which the tube is designed to pass current.
- 1E44. **Peak Inverse Anode Voltage.** Peak inverse anode voltage is the maximum instantaneous anode voltage in the direction opposite to that in which the tube is designed to pass current.
- 1E45. **Tube Voltage Drop.** Tube voltage drop in a gas or vapor-filled tube is the anode voltage during the conducting period.
- 1E46. **Electrode Dissipation.** Electrode dissipation is the power dissipated in the form of heat by an electrode as a result of electron and/or ion bombardment.
- 1E47. **Ionization Current.** Ionization current is the electric current resulting from the movement of electric charges in an ionizing medium under the influence of an applied electric field.
- 1E48. **Gas Current.** Gas current is a current flowing to an electrode and composed of positive ions which have been produced as a result of gas ionization by an electron current flowing between other electrodes.
- 1E49. **Leakage Current.** Leakage current is a conductive current which flows between two or more electrodes by any path other than across the vacuous space.
- 1E50. **Electrode Admittance.** Electrode admittance is the quotient of the alternating component of the electrode current by the alternating component of the electrode voltage, all other electrode voltages being maintained constant. As most precisely used, the term refers to infinitesimal amplitudes.
- 1E52. **Electrode Conductance.** Electrode conductance is the quotient of the in-phase component of the electrode alternating current by the electrode alternating voltage, all other electrode voltages being maintained constant. This is a variational and not a total conductance. As most precisely used, the term refers to infinitesimal amplitudes.
- 1E53. **Electrode Resistance.** Electrode resistance is the reciprocal of the electrode conductance. This is the effective parallel resistance and is not the real component of the electrode impedance.
- 1E54. **Transadmittance.** Transadmittance from one electrode to another is the quotient of the alternating component of the current of the second electrode by the alternating component of the voltage of the first electrode, all other electrode voltages being maintained constant. As most precisely used, the term refers to infinitesimal amplitudes.
- 1E55. **Transconductance.** Transconductance from one electrode to another is the quotient of the in-phase component of the alternating current of the second electrode by the alternating voltage of the first electrode, all other electrode voltages being maintained constant. As most precisely used, the term refers to infinitesimal amplitudes.
- 1E56. **Control-Grid-Plate Transconductance.** Control-grid-plate transconductance is the name for the plate-current-to-grid-voltage transconductance. This is ordinarily the most important transconductance and is commonly understood when the term "transconductance" is used.
- 1E60. **Conversion Transconductance.** Conversion transconductance is the quotient of the magnitude of a single beat-frequency component ($f_1 + f_2$) or ($f_1 - f_2$) of the output-electrode current by the magnitude of the control-electrode voltage of frequency f_1 , under the conditions that all direct electrode voltages and the magnitude of the electrode alternating voltage f_2 remain constant and that no impedances at the frequencies f_1 or f_2 are present in the output circuit. As most precisely used, the term refers to an infinitesimal magnitude of the voltage of frequency f_1 .
- 1E61. **μ Factor.** μ factor is the ratio of the change in one electrode voltage to the change in another electrode voltage, under the conditions that a specified current remains unchanged and that all other electrode voltages are maintained constant. It is a measure of the relative effect of the voltages on two electrodes upon the current in the circuit of any specified electrode. As most precisely used, the term refers to infinitesimal changes.

- 1E62. **Amplification Factor.** Amplification factor is the ratio of the change in plate voltage to a change in control-electrode voltage under the conditions that the plate current remains unchanged and that all other electrode voltages are maintained constant. It is a measure of the effectiveness of the control-electrode voltage relative to that of the plate voltage upon the plate current. The sense is usually taken as positive when the voltages are changed in opposite directions. As most precisely used, the term refers to infinitesimal changes. Amplification factor is a special case of μ factor.
- 1E63. **Electrode Characteristic.** An electrode characteristic is a relation, usually shown by a graph, between an electrode voltage and current, other electrode voltages being maintained constant.
- 1E64. **Transfer Characteristic.** A transfer characteristic is a relation, usually shown by a graph, between the voltage of one electrode and the current to another electrode, all other voltages being maintained constant.
- 1E65. **Interelectrode Capacitance.** Interelectrode capacitance is the direct capacitance between two electrodes.
- 1E66. **Electrode Capacitance.** Electrode capacitance is the capacitance of one electrode to all other electrodes connected together.
- 1E67. **Input Capacitance.** The input capacitance of a vacuum tube is the sum of the direct capacitances between the control grid and the cathode and such other electrodes as are operated at the alternating potential of the cathode. This is not the effective input capacitance, which is a function of the impedances of the associated circuits.
- 1E68. **Output Capacitance.** The output capacitance of a vacuum tube is the sum of the direct capacitances between the output electrode (usually the plate) and the cathode and such other electrodes as are operated at the alternating potential of the cathode. This is not the effective output capacitance, which is a function of the impedances of the associated circuits.
- 1E69. **Class A Amplifier.** A Class A amplifier is an amplifier in which the grid bias and alternating grid voltages are such that plate current in a specific tube flows at all times.
- 1E70. **Class AB Amplifier.** A Class AB amplifier is an amplifier in which the grid bias and alternating grid voltages are such that plate current in a specific tube flows for appreciably more than half but less than the entire electrical cycle.
- 1E71. **Class B Amplifier.** A Class B amplifier is an amplifier in which the grid bias is approximately equal to the cutoff value so that the plate current is approximately zero when no exciting grid voltage is applied and so that plate current in a specific tube flows for approximately one half of each cycle when an alternating grid voltage is applied.
- 1E72. **Class C Amplifier.** A Class C amplifier is an amplifier in which the grid bias is appreciably greater than the cutoff value so that the plate current in each tube is zero when no alternating grid voltage is applied, and so that the plate current in each tube is zero when no alternating grid voltage is applied, and so that plate current in a specific tube flows for appreciably less than one half of each cycle when an alternating grid voltage is applied. To denote that grid current does not flow during any part of the input cycle, the suffix 1 may be added to the letter or letters of the class identification. The suffix 2 may be used to denote that grid current flows during some part of the cycle.

PRINCIPLES AND FUNDAMENTALS OF OPERATION

CONSTRUCTION OF TRANSMITTING TUBES

Cathodes

Three cathodes commonly used in transmitting tubes are those of pure tungsten, thoriated tungsten, and oxides of a mixture of barium, strontium and calcium. The choice of cathode in the design of an electronic tube depends on a number of factors; the most important ones are discussed here.

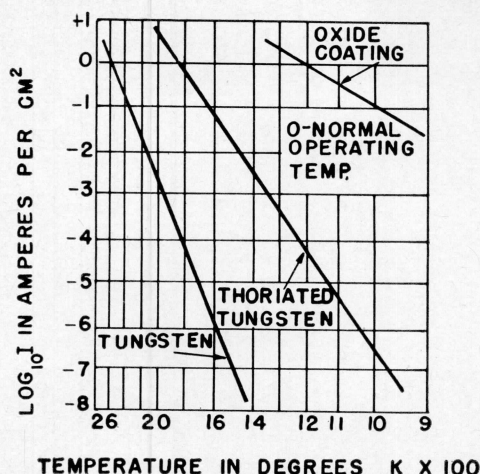
Tungsten—The pure metal cathode is suited for use in tubes operating at high voltages. The principal advantage of pure tungsten is its long

life. Positive ion bombardment, resulting from residual gases in the tube, has little effect on the quality of the emitter. The tungsten metal is continuous through the cross section of the cathode, and the emissive area remains substantially constant. Another important advantage of tungsten filament is its mechanical strength, a highly desirable feature in the design of the larger transmitting tubes.

Thoriated Tungsten—Formed of tungsten infused with thorium, this cathode is widely used in tubes of intermediate voltage ratings. In proc-

CONSTRUCTION OF TRANSMITTING TUBES (CONT'D)

essing this type of cathode, an overlayer of pure thorium is formed, and this material,



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Fig. 1—Emission Versus Temperature for Various Cathodes

which emits at a lower temperature than tungsten, is used as the active surface. Its efficiency is greater than that of tungsten, and for a given bulb size, allows higher ratings to be applied to other electrodes in the tube.

Coated—Coated cathodes are constructed in two general forms. One type has the emissive oxide formed directly on the surface of the heater. The other has a coated sleeve and separate, insulated heater. These types are widely used in receiving and low voltage transmitting tubes because of their relatively high emission efficiency.

The separately, or indirectly heated cathode is an equipotential surface and is insulated from the heater, permitting operation of the cathode at potentials differing from those of the heater circuit. This feature is especially valuable in circuit problems involving self-bias, current feedback, or impedance transformation. The curves of Fig. 1, illustrate the relation between emission and temperature for various cathodes.

Grids—The choice of a suitable material for grid structures in transmitting tubes is generally made between tungsten, tantalum, and molybdenum. All of the materials possess good mechanical strength, an important consideration in avoiding small deformations which may greatly alter characteristics of the tube. Tantalum, easily welded, proves particularly desirable for grids which are formed by spiraling and welding wire to supports. Tantalum also displays excellent gettering qualities when properly treated, and low primary and secondary emission.

Plates—A wide variety of materials have found favor in the design of transmitting tube plates. For convection-cooled tubes, tantalum, molyb-

denum, graphite, zirconium coated base metals, and carbonized nickel are extensively used at the present time.

Tantalum—Tantalum is widely used for plates in transmitting tubes; it is easily formed and welded, and its high melting point allows correspondingly high dissipation ratings. Its excellent gettering action makes it a nearly ideal material for use in high-voltage tubes.

Molybdenum—Molybdenum is similar to tantalum in general properties. It displays a comparatively low emissivity versus temperature characteristic and good heat conductivity. The addition of fins and surface roughening by carborundum blasting is often employed to increase the heat radiating ability of molybdenum plates.

Graphite—Graphite plates are commonly employed in small transmitting tubes. They can be formed in a great variety of shapes, and, if properly processed, have good thermal emissivity. The graphite plate is usually rather thick to provide good mechanical strength. This, plus the fact that it is a black body, help to make it an excellent radiator.

Carbonized Nickel—Nickel has the advantages of economy and workability and is easily subjected to any number of mechanical processes. By itself, this metal does not always possess the desired radiation qualities and is, therefore, often carbonized to blacken and roughen the surface. This process affords increased radiation ability.

Zirconium—Zirconium coatings are used on base metals such as molybdenum, tungsten, and nickel. It is a dark, dull metal with excellent properties as a radiator and, if properly processed, a first class getter. Although zirconium coated plates approach tantalum as an ideal plate material, their vapor pressure and melting point are not quite as favorable. One of the chief advantages of zirconium coatings is that an easily worked base metal may be formed in any desired shape and then coated.

Copper—In forced-air cooled tubes of the exposed plate type and in water-cooled tubes, oxygen-free copper is the standard material. Of the common metals, copper has the highest heat and electrical conductivity. It is easily formed in a great variety of shapes by spinning, drawing and machining. Molecular hydrogen, generally present to a certain extent in the cooling water, does not pervade copper plates to any serious extent as it will with many other metals.

Inverted Anode Construction—An especially interesting form of high-frequency tube construction was pioneered by the General Electric Company in 1941. As the practical upper limit of the frequency spectrum moved higher, accepted approaches in tube design became impractical and, in some cases, impossible.

CONSTRUCTION OF TRANSMITTING TUBES (CONT'D)

A number of apparently conflicting requirements for high-frequency operation had to be satisfied. Small electrode spacings, for high transconductance and minimum transit time effects, conflicted with the need for high dissipation ability and voltage insulation; large electrode areas to satisfy the power requirements affected the maximum frequency of operation because of their inherently high capacitance and inductance; and proper voltage insulation seemed incompatible with short lead length and low lead inductance.

The GL-880 (see cross-sectional view of fig. 2) represents a successful solution of these problems. This tube was designed for 20 kilowatts plate dissipation and with maximum ratings applying up to 25 megacycles. The anode is inverted, that is, folded back on itself twice, reducing the lead length approximately 10 inches below that required in previous designs, without sacrifice of good cooling properties and insulation factor.

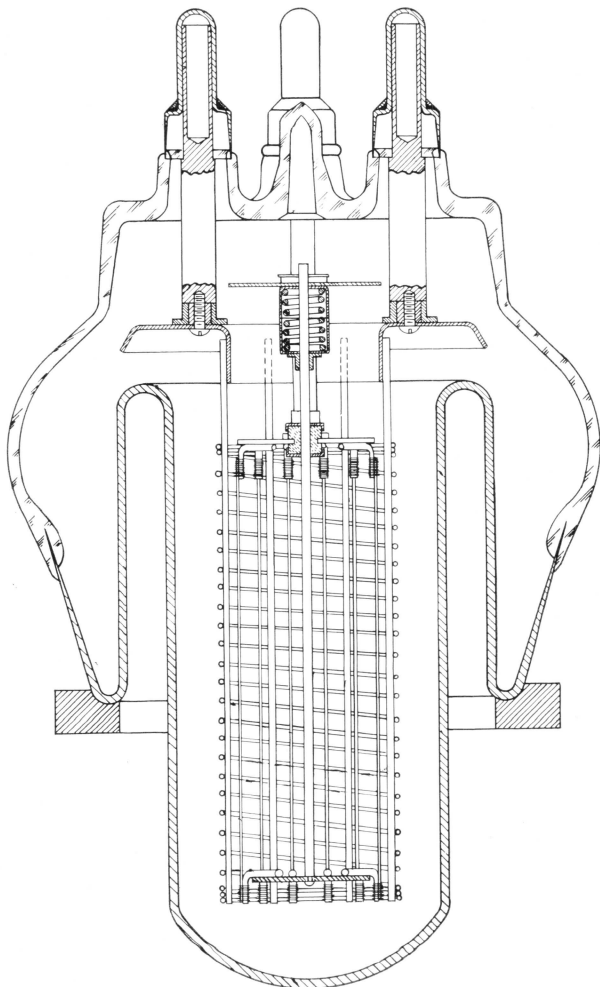


Fig. 2—Cross-sectional View of GL-880

Fin Coolers—The GL-8002-R, illustrated in cross-sectional view of Fig. 3, is an example of the fin cooled high-frequency tube. The same tube without the radiator fins is available for water-cooled service.

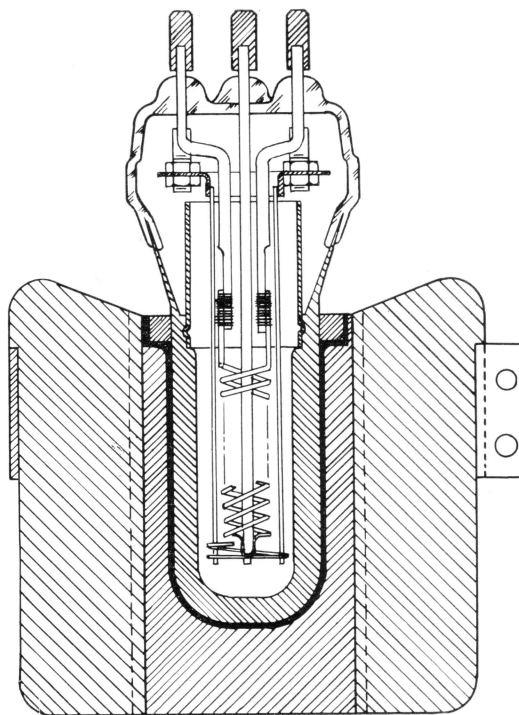


Fig. 3—Cross-sectional View of GL-8002-R

The fin cooler for the GL-8002-R is designed for optimum cooling performance in order to result in the smallest possible size consistent with air-velocity and air-volume limitations. The cooler itself consists of 60 copper fins silver soldered to a copper hub. A retainer band encloses a portion of the fin length to facilitate mounting in the air duct. The GL-8002-R is widely used in frequency-modulation transmitters. In pairs these tubes develop three kilowatts at frequencies ranging to 120 megacycles.

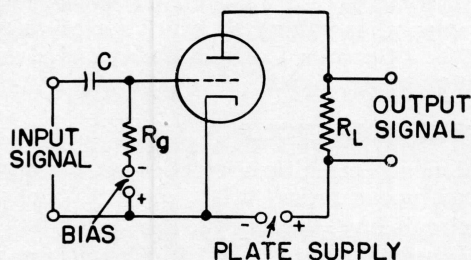
GENERAL CLASSES OF OPERATION

Amplifiers

Amplifiers are classified into four general groups, A, AB, B, and C. These designations are standard throughout the industry and are used in all technical data. This method of classification is based primarily on the plate current characteristic under full-load operation. A further distinction is made between circuits in which grid current does not flow and those in which grid current flows for at least part of the cycle. The former is indicated by the suffix 1 appended to the general designation and the latter by suffix 2.

Class A

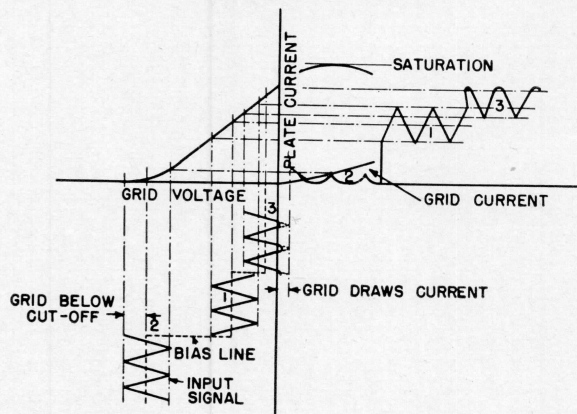
In an ideal Class A system, amplification is accomplished without distortion. As a rule, Class A amplifiers are not operated in the positive grid region although such operation is possible if the driving source is capable of supplying enough energy to sustain the wave form. In no case may it be driven below plate current cutoff. Fig. 4 shows a conventional triode Class A amplifier, and Fig. 5 demonstrates the wave forms for various conditions of operation from a high impedance source.



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Fig. 4—Triode Class A Amplifier

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Fig. 5—Wave Forms for Class A Amplifier Operation

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When operating in region 1, the I_p - E_g characteristic is straight, and linear amplification takes place. In region 2, the tube is biased near cutoff, and the output wave is clipped. Due to the curvature of the characteristic near cutoff, distortion of the unclipped portion of the wave also occurs. In region 3, the grid is driven into the positive range and grid current flows causing wave form distortion, which results in a similar distortion of the output wave form. Distortion

may also be caused by driving the tube to current saturation, or with a strong driving source, the positive grid current may become a large portion of the total current available from the cathode.

Class AB

The region of operation of Class AB amplifiers as well as that of other types is shown in Fig. 5. In an AB amplifier, the grid bias is somewhat lower than in a Class A system, and plate current reaches zero for a portion of the negative excursion of the input signal. Because of the bias condition, the average value of plate current is lower and the efficiency of the amplifier higher than in a Class A amplifier. Distortion is introduced, of course, in this type of amplifier. In the audio range this is limited by using push-pull circuits.

Class B

In a Class B amplifier, grid bias is held approximately equal to the cutoff voltage. Plate current is close to zero without excitation and flows during the positive half cycle of the grid signal. Here, as in the class AB amplifier, special precautions must be taken to reduce distortion.

Class C

In a Class C amplifier the grid bias is at a value appreciably lower than that necessary for cutoff, the plate current flows only under grid drive, and then only for portion of the positive excursion of the signal. It is used almost exclusively at radio frequencies with resonant circuits in the plate.

Oscillators

Oscillators are, in general, a special case of amplifier service. Their general theory is discussed in the "application section."

Rectifiers

Rectifier tubes fall into two main groups: high-vacuum and mercury-vapor. The first group is especially suited for high-voltage applications where the inverse voltage across the tube may rise to very high values (see applications circuits). Mercury-vapor tubes are characterized by a practically constant internal voltage drop and high current capacity. This constant drop feature is often utilized in systems which require close regulation of the d-c voltage over a large range of load currents.

RATINGS OF TRANSMITTING TUBES

General

Transmitting tubes are rated by the "absolute" system. In this system, the maximum ratings listed for a particular type give the limiting value above which the operating life may be seriously affected. The equipment designer should, therefore, consider these ratings as absolute limits which cannot be exceeded.

Line voltage variations, supply regulation, manufacturing tolerances in production equipment, etc., must be taken into account in the design program.

In some instances both CCS and ICAS ratings have been listed for a tube. The first, CCS (Continuous Commercial Service) applies to equipment in which long life and reliable opera-

tion are of primary importance. Almost all commercial installations are designed by these ratings. Where factors of weight, cost, and size vs. power output appear most important, the ICAS (Intermittent Commercial and Amateur Service), rating may be applied. Intermittent service is generally considered to be service in which the operating period never exceeds five minutes, and the stand-by interval is at least equal to this operating period.

Filament Circuit—Filament and heater ratings are invariably given in terms of average voltage. Nominal current at rated voltage is included only as an aid in equipment design. The filament circuit should be so regulated as to limit the possible voltage deviation to ± 5 per cent of the

rated value unless otherwise specified on the data sheet.

Plate Circuit—In the plate ratings of transmitting tubes, the operating frequency of the tubes is an important parameter. Wherever a tube is designed for high-frequency operation, the data sheet includes a tabulation of the maximum permissible percentage of maximum rated plate voltage and plate input as a function of frequency.

It will be noted that in most cases the product of maximum plate voltage and maximum plate current is higher than the maximum permissible plate dissipation. Plate current as a function of plate voltage, or voltage as a function of current should be determined on the basis of the rated maximum dissipation.

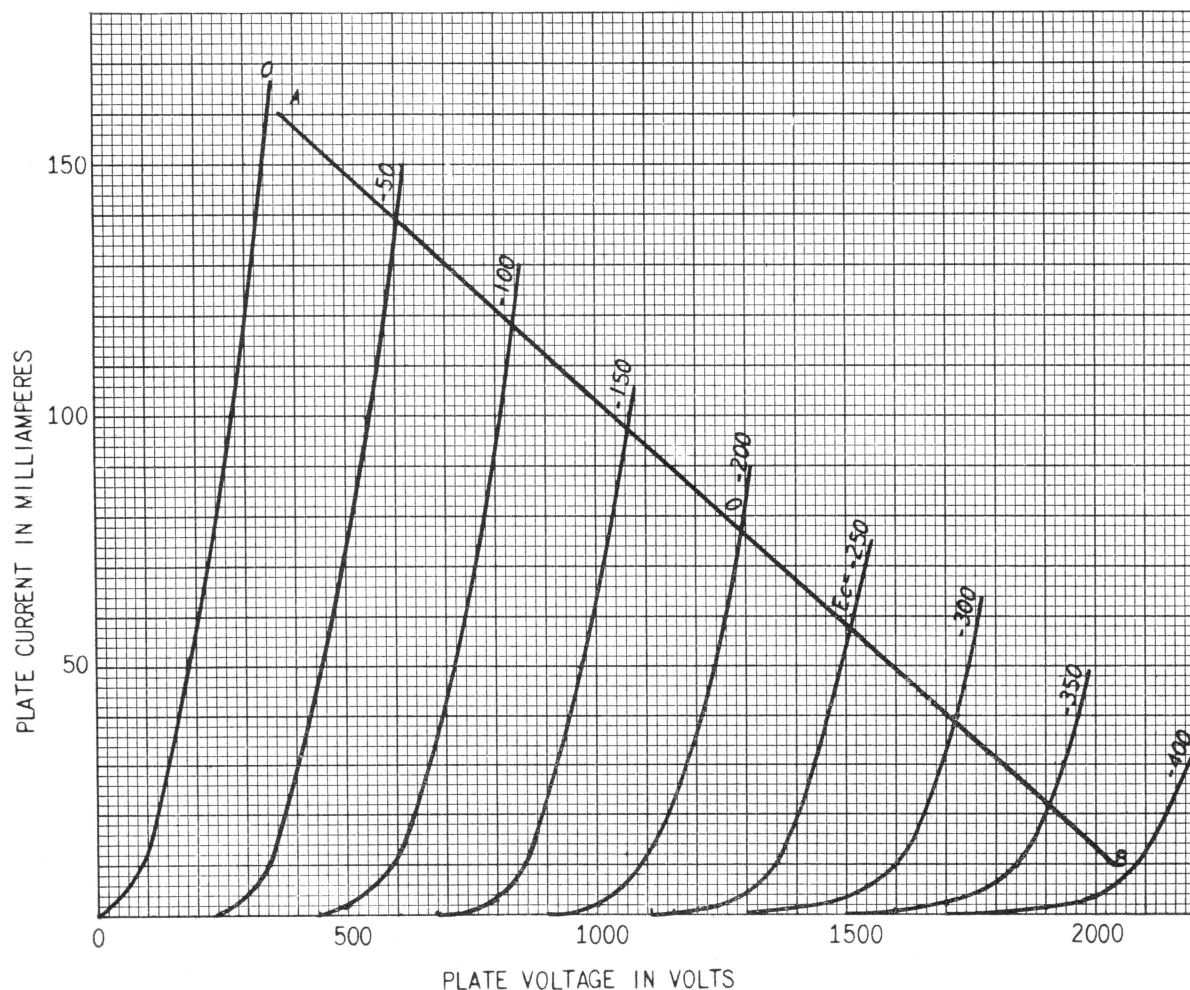
CALCULATION OF TUBE OPERATING CONDITIONS

General

In order to make optimum adjustment of transmitting tube operating conditions, it is necessary to visualize clearly the effect on tube

operation, and hence on circuit output, of varying grid bias voltage, grid drive, plate voltage and plate circuit impedance.

A complete sample set of calculations will



be made for the various classes of operation, using the GL-889-A as an example except for the Class A amplifier analysis in which the GL-845 is used. All of the work for Class B and C operation is based on use of the "constant-current" curves. Experience has shown that the results so obtained compare closely with actual operating test results.

Several sets of calculations should be made for any particular class of operation to be sure that the optimum conditions are met as far as plate efficiency and grid drive are concerned. Operating conditions should be chosen so as to always fall within the maximum ratings.

For Class A Amplifiers (Resistance Loads)

The Class A amplifier analysis is based on characteristic curves of the GL-845 tube which is particularly suited for Class A operation, rather than on the curves of the GL-889-A which is designed for other classes of service. Also tube applications do not generally require a tube of high-power rating for Class A service, since operating efficiency of high-power tubes becomes an important factor and Class B linear service is desirable.

Referring to Fig. 6 of page 8, it is first necessary to draw the load line A-B about the operating point O. The following factors should be considered in locating the operating line:

- (1) The point O must be located so that the product of the plate current and plate voltage at that location does not exceed the maximum rated anode dissipation.
- (2) The position of point O on a proposed operating line must be such that the grid swing does not go past the zero bias curve, as shown at A. At the extreme negative grid swing, point B, operation should not extend appreciably into the non-linear portion of the curves. In general, point B should not be below 10 to 15 per cent of the plate current at point O. The grid swing from O to A is equal to the grid swing from O to B.
- (3) The calculations will show that the power output is proportional to the product of the total plate current and plate voltage change when operating over the load line from A to B. Thus it is apparent that lowering the point O would reduce the possible plate current swing and therefore the power output. To raise it, would cause the anode dissipation rating to be exceeded, as explained above.

Having thus located the line A-B, Fig. 6, it is possible to calculate specific conditions of tube operation, as follows:

$$(1) \text{ Power output} = \frac{(E_{\max} - E_{\min})(I_{\max} - I_{\min})}{8}$$

From Fig. 6:

$E_{\max}$ = plate voltage at B = 2030 volts

$E_{\min}$ = plate voltage at A = 380 volts

$I_{\max}$ = plate current at A = 0.159 amperes

$I_{\min}$ = plate current at B = 0.010 amperes

$$\text{Power output} = \frac{(2030 - 380)(0.159 - 0.010)}{8} = 30.6 \text{ watts}$$

- (2) Plate dissipation is the product of the plate current and the plate voltage at operating point O. Plate dissipation, from Fig. 6 = $0.080 \times 1250 = 100$ watts.

- (3) Required load resistance is equal to the ratio of the plate voltage change to the plate current change, on the load line A-B. From Fig. 6 the load resistance is calculated as follows:

Plate current at A = 159 milliamperes

Plate current at O = 80 milliamperes

Plate voltage at A = 380 volts

Plate voltage at O = 1250 volts

$$R_L = \frac{1250 - 380}{159 - 80} = 11,000 \text{ ohms}$$

- (4) The d-c plate current will be equal to the value of plate current at the point O, or from Fig. 6, this value is 80 milliamperes.
- (5) Some distortion is always present due to non-linearity. This distortion is comprised almost entirely of a second harmonic. The allowable percentage of second harmonic is generally specified at 5 per cent maximum and may be calculated from the following relation:

$$\text{Percentage 2nd harmonic} = \frac{\frac{1}{2}(I_{\max} + I_{\min}) - I_o \times 100}{I_{\max} - I_{\min}}$$

Where, referring to Fig. 6:

$I_{\max}$ = plate current at A = 159 ma.

$I_{\min}$ = plate current at B = 10 ma.

I_o = plate current at O = 80 ma.

then percentage second harmonic is:

$$\frac{\frac{1}{2}(159 + 10) - 80}{159 - 10} \times 100 = 2.8 \text{ per cent}$$

The above calculations set up conditions of operation which would deliver the maximum power possible, yet not exceed any of the maximum ratings of the tube. Several sets of calculations may be required to obtain the optimum operating conditions to fulfill other special requirements, such as operation at reduced power output, reduced plate voltage, different load impedance or combination of the above.

CALCULATION OF TUBE OPERATING CONDITIONS (CONT'D)

For Class C Radio-frequency Amplifiers and Oscillators

Certain conditions of operation are arbitrarily assigned, as follows:

- 1. D-c plate voltage = 7500 volts
- 2. Grid bias voltage = - 800 volts
- 3. Peak grid voltage swing = 1800 volts
- 4. Plate voltage swing = 6000 volts

All the above values may be obtained in practice by applying them directly or by varying the grid drive or load impedance.

Referring to Fig. 7, the first step is to determine the operating line A-A', as established by the four assigned conditions of operation. The point A is determined by the d-c plate voltage and grid bias voltage. As the plate voltage swings down and the grid voltage rises in sinusoidal fashion, their instantaneous values describe a straight line, terminated at A'. The point A' is automatically determined, having chosen A as the starting point and having previously determined the amplitude of grid and plate voltage swing.

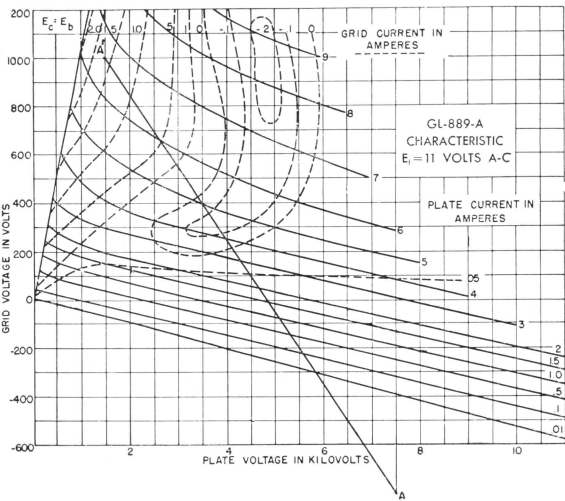


Fig. 7—GL-889-A Characteristic Curves with A-A' Line

CLASS C AMPLIFIER AND OSCILLATOR SERVICE

Angle Degrees	Sine	e_p Volts	i_p Amperes	Product Sine Amperes	e_g Volts	i_g Amperes	Product Sine Amperes
0	0	7500		—	-800		—
5	.087	6978			-643		
15	.258	5950			-335		
25	.423	4960	1.25	.529	-40		
35	.574	4060	3.80	2.18	230	-0.020	-0.0115
45	.707	3260	5.20	3.68	470	0.020	0.0141
55	.819	2600	6.0	4.91	670	0.50	0.409
65	.906	2070	6.4	5.80	830	0.90	0.815
75	.966	1700	6.5	6.28	940	1.25	1.208
85	.996	1520	6.5	6.48	990	1.70	1.692
90	1.00	1500	(*)	—	1000	(*)	—
5-85 Incl.		Summation	35.65	29.85		4.35	4.126
		Divide By	18	18		18	18
Average Current		$I_b =$	1.98	1.66	$(I_g) =$	.242	.229
0°		$E_b =$	7500		$E_c =$	-800	
90°		$e_p =$	1500		$e_g =$	1000	
Difference (Swing)		6000		(Swing)	1800		
Plate Input = $E_b \times I_b =$		7500	×	1.98			= 14.85 kilowatts
Plate Output = Plate Swing $\times$ Average Product Sine Amperes =		6000	$\times$	1.66			= 9.95 kilowatts
Efficiency = $\frac{\text{Output}}{\text{Input}} =$				9.95			= 67 per cent
Total Grid Excitation Power = Grid Swing $\times$ Average Product Sine Amperes							= 410
Grid Bias Loss = $I_g \times E_c =$		800	$\times$	.242			= 193

*Peak value—for reference only—omit from calculation of average currents.

Fig. 8—Chart Showing Calculation of GL-889-A Typical Operating Conditions

The point A is set at a point corresponding to a plate voltage of 7500 volts and grid bias of -800 volts. With a grid swing of 1800 volts and a plate swing of 6000 volts, the point A' is located at a grid voltage of 1000 volts and a plate voltage of 1500 volts. Thus the operating line A-A' is determined.

The rest of the work is simply mechanical integration. The instantaneous values of plate voltage and current, and grid voltage and current are tabulated as shown in table of Fig. 8, page 10. By simple relations indicated in Fig. 8, the operating conditions are completely determined.

By studying this set of calculations, it is possible to determine:

1. D-c plate input power
2. Plate output power
3. Plate efficiency
4. Grid excitation power
5. Grid bias loss
6. D-c grid current

It will be found that the location of the point A' on the curves of Fig. 7, affects the tube operation very greatly since a small change in its position changes the working range in the high grid current and plate current region.

A few sets of calculations will indicate the optimum operating conditions for a particular installation. By referring to Fig. 9, a general idea may be gained as to the relation of the performance factors involved.

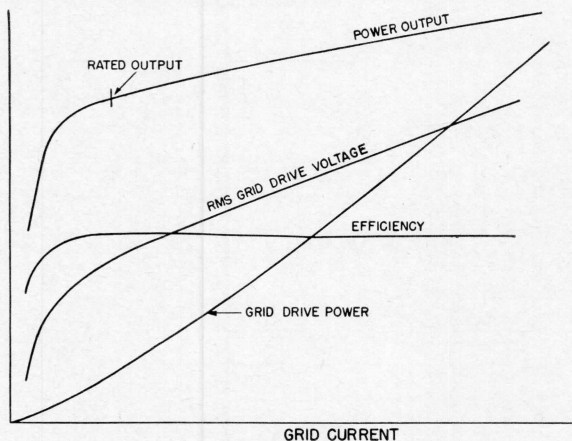
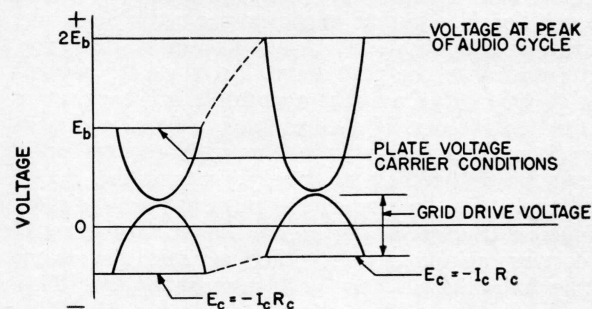


Fig. 9—Performance Curves for Class C Amplifier and Oscillator

For Class C Radio-frequency Power Amplifiers, Plate Modulated

The operation of a tube under plate modulation conditions may be analyzed in a manner similar to that for a Class C oscillator, unmodulated. In this type of service, operating conditions are specified for carrier conditions. Modulation is used by superimposing the signal voltage on the applied d-c plate potential. 100

per cent modulation means that the applied plate potential varies from zero to twice the d-c applied voltage throughout the audio cycle as shown in Fig. 10.



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Fig. 10—Wave Shapes Showing Plate Voltage Variation

In establishing the operating lines for plate modulated service, the carrier conditions are determined. It will be noted that the maximum anode dissipation for carrier conditions is less than that for Class C oscillator rating. This must be so since 100 per cent modulation causes the plate input and plate dissipation to increase 50 per cent, the additional plate input being supplied by the modulator.

When establishing the operating line for carrier conditions, it must be borne in mind that a second line must be drawn for conditions obtained at double the d-c plate voltage. This second line corresponds to the conditions under which the tube is operating, at the peak of the modulating voltage. Certain relations, as enumerated below, must exist between these two lines in order that the output be free from distortion.

(1) If the modulation is to be free from distortion, a linear relation must exist between the radio-frequency voltage and current. Therefore, for 100 per cent modulation, at the peak of the modulation cycle, the radio-frequency voltage and current must be double that of the carrier condition, while at the other extreme of the modulation cycle the radio-frequency voltage and current are zero. It should be noted that the r-f current is proportional to the average current calculated under the column "Product Sine Amperes" in Fig. 8.

(2) The operating line for the peak of the modulation cycle must be drawn so that the load impedance will be the same as that for the operating line at carrier conditions. The load impedance may be expressed by the relation $\frac{E_p^2}{2P_o}$,

where E_p = plate voltage swing, and P_o = power output in watts.

(3) It will be found upon examination of the constant current curves that in order to double the current, at double the voltage when operat-

CALCULATION OF TUBE OPERATING CONDITIONS (CONT'D)

ing at the peak of the audio cycle, it will be necessary to work to rather high peak currents. This will require that the grid be driven to a considerably higher positive peak than for the carrier conditions. It is not generally desirable to modulate the grid drive, but the higher positive grid drive may be accomplished in practice by two factors. If a combination fixed and grid resistor bias is used, the bias voltage developed will be reduced at the peak of the audio cycle. This will be true since the minimum plate voltage on this operating line is higher than for the carrier operating line, which results in working the tube in a lower grid current region. This reduces the grid current, and hence the bias voltage. Thus, with constant grid excitation the positive grid voltage peak will be raised by the amount of reduced grid bias. In actual practice, with reduced loading of the grid excitation supply, the grid drive voltage will increase to some extent, thus increasing further the positive peak grid voltage.

For Class B Audio Amplifiers

Operating conditions and calculations are those for a two-tube push-pull amplifier, since this is the type of circuit generally encountered in this class of service.

The applied conditions of operation must first be determined as follows:

- (1) The d-c plate voltage is arbitrarily assigned to be 7500 volts.
- (2) The plate current is to be chosen for zero signal input.

Fig. 11 represents a composite plate characteristic curve for two tubes.¹ Use of this curve clarifies the analysis which is complicated by the fact that the plate currents of the two tubes act on a common magnetic circuit in the output transformer. The composite curve is formed by placing two sets of static plate characteristic curves back to back as indicated in the figure.

Since the plate currents for the two tubes act through the output transformer in opposite directions, only their differences contribute to useful output. Therefore, the dotted lines indicate useful composite plate characteristics for the two tubes, the grid voltage lines now corresponding to signal voltages.

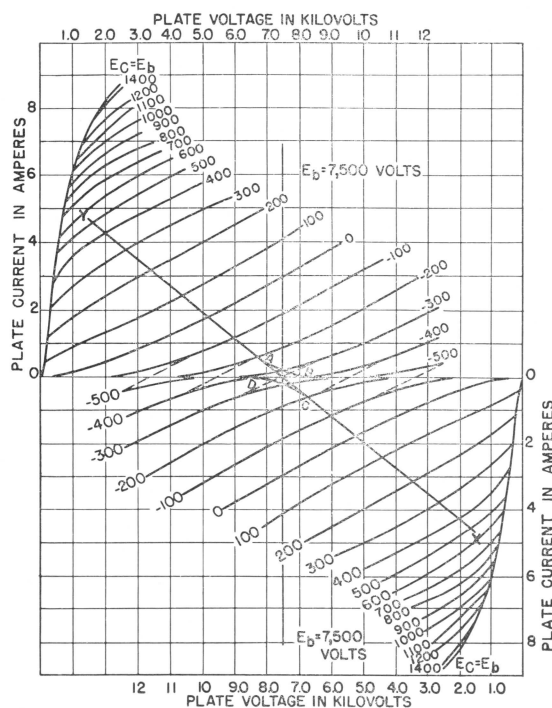
The output operating line is shown as X-Y. The individual tube operating lines are YAB and XCD.

The individual tube operating lines of Fig. 11 are based on a zero signal plate current of 0.2 ampere. In general a value of 10 to 15 per cent of the average plate current is used. If too high a value of zero signal current is used, the distortion, and plate dissipation will be excessive.

(3) The grid bias voltage is established, since a d-c plate voltage of 7500 volts, and a zero signal plate current of 0.2 ampere has been chosen for this set of calculations. From the plate current curves, this would require -300 volts bias.

(4) Assume a peak positive grid voltage of 550 volts. This is an arbitrary value, and may be applied by a suitable driving stage. The peak grid swing is then 850 volts. If too high a value of positive grid voltage is chosen, the driving power will be greatly increased with little increase in power output.

(5) For this set of calculations a plate voltage swing of 6000 volts will be used. This again is an arbitrary value, and ordinarily is approximately 80 per cent of the d-c plate voltage. If too low a minimum plate voltage dip is used, excessive distortion and grid drive will result. If too high a minimum plate voltage dip is used, plate efficiency is sacrificed. The value of the load impedance in the plate output circuit to give this swing will be determined from the ratio of the plate voltage swing to the peak plate current as determined later in the calculations.



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Fig. 11—Composite Plate Characteristic Curve for Combined Tubes and Transformer (Class B Audio Service)

¹ B. J. Thompson, "Push-Pull Audio Amplifier," Proceedings of the I.R.E. (April, 1933), p. 591.

Summarizing the above, the following conditions of operation have been established thus far:

- (1) D-c plate voltage = 7500 volts
- (2) Grid bias voltage = -300 volts
- (3) Peak grid voltage swing = 850 volts. This results in a maximum positive grid voltage of 550 volts, at maximum signal.
- (4) Peak plate voltage swing = 6000 volts. This results in a minimum plate voltage dip of 1500 volts at maximum signal.

The above conditions completely determine the operating line X-Y, Fig. 11.

Efficient operating conditions for Class B audio amplifiers normally result in some distortion. This can be tolerated since the even order harmonics are eliminated from the output in the push-pull amplifier. However, this makes it impossible to draw a straight operating line between points A and B of Fig. 12, as was done in the case of the Class C amplifier for calculation of operating conditions. However, items 1 through 4 above do define the extreme points of grid and plate voltage and current excursions as shown by points X and Y, of Fig. 11, and A and B, Fig. 12.

Reference is again made to Fig. 11. The load line X-Y must be straight, since the load current must vary directly with the plate voltage, the load impedance being constant. Working from Fig. 11, the operating line A-B of Fig. 12, is laid out so that the grid voltage for any value of plate voltage correspond on the two curves. For example, on Fig. 11 for a grid of voltage plus 300 the plate voltage is 2700. This then deter-

mined one of the points, P along which the curve A-B, Fig. 12, was to lie. Having laid out the operating line A-B, Fig. 12, it remains to calculate the tube operation as shown in the chart of Fig. 13.

Complete tube performance may thus be determined for the chosen set of conditions, as follows:

- (1) D-c plate input kw (per tube)
- (2) Plate output power (per tube)
- (3) Plate dissipation
- (4) Plate efficiency
- (5) Grid excitation power
- (6) Load resistance—plate to plate
- (7) D-c grid current
- (8) Grid bias loss

All of the above results are for maximum signal operation. The maximum anode dissipation, however, will be found to occur at a signal less than unity, approximately at $S = \frac{2}{K}$ where:

K = ratio of plate voltage swing to the d-c plate voltage, at maximum signal $S = 1$.

S = ratio of the signal under consideration (grid swing), to the maximum signal, as used in the sample calculation.

Thus for the conditions of operation chosen for the sample calculation the signal for maximum anode dissipation is determined as follows:

$$K = \frac{6000}{7500} = 0.80$$

$$S = \frac{2}{0.8 \times 3.14} = 0.794$$

The maximum signal grid swing ($S = 1$), in the example, Fig. 13, was 850 volts. For $S = 10.794$, the grid swing will be 675 volts, with a maximum positive grid voltage peak of 375 volts. The operating line for $S = 0.794$ is then A-C, Fig. 12. Carrying through calculations for this operating line, similar to those in the chart of Fig. 13, it will be found that the anode dissipation is 4.42 kilowatts. Since this value is within the rated anode dissipation of the tube, the conditions chosen for operating line A-B are satisfactory.

If the operating line A-B deviates greatly from a straight line, it is an indication that distortion is present, and the output should be checked for harmonic content.

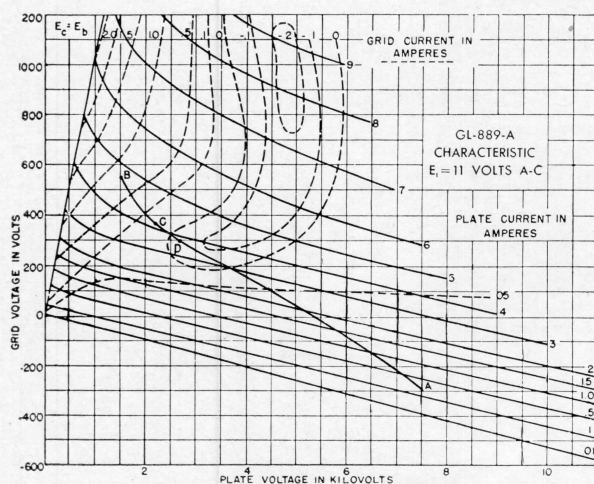


Fig. 12—GL-889-A Characteristic Curves with A-P-C-B Line

CALCULATION OF TUBE OPERATING CONDITIONS (CONT'D)

TYPE GL-889A CALCULATION OF TYPICAL OPERATING CONDITIONS BY _____ DATE _____
CLASS B AUDIO AMPLIFIER SERVICE

Angle Degrees	Sine	e_p Volts	Plate Swing Volts	i_p Amperes	Product Plate Swing and i_p	e_g Volts	i_g Amperes	Product Sine Amperes
0	0	7500			—	—300		—
5	0.087	7000	500	.5	250	—226		
15	0.258	5900	1900	1.3	2,080	—81		
25	0.423	4800	2700	2.1	5,670	+59	0.05	0.021
35	0.574	3700	3800	2.95	11,200	187		
45	0.707	2700	4800	3.8	18,250	300		
55	0.819	2100	5400	4.2	22,700	395	0.10	0.082
65	0.906	1800	5700	4.5	25,700	470	0.40	0.362
75	0.966	1600	5900	4.6	27,100	520	0.70	0.676
85	0.996	1500	6000	4.7	28,200	547	0.75	0.746
90	1.00	1500		(*)	—	550	(*)	—
5 85 Incl. Summation Divided By				28.65	141,150		2.00	1.887
Average Current $I_b =$				18	18		18	18
0° $E_b = 7500$				159		(I_g) =	0.111	0.105
90° $e_p = 1500$						$E_c = -300$		
Difference (Swing) 6000						$e_g = 550$		
						(Swing) 850		

Plate Input = $E_b \times I_b = 7500 \times 1.59$ = 11.92 kilowatts
Plate Output = $\frac{141.50}{18}$ = 7.83 kilowatts
Plate Dissipation = Plate Input—Plate Output = 4.09 kilowatts
Efficiency = $\frac{\text{Output}}{\text{Input}} = \frac{7.83}{11.92}$ = .656%
Total Grid Excitation Power = Grid Swing $\times$ Average Product Sine Amperes = = 89.2 watts
Grid Bias Loss = $I_g \times E_c = .111 \times 300$ = 33 watts

* Peak value—for reference only—omit from calculation of average currents.

Load Resistance = $\frac{\text{Peak plate voltage swing} = 6000}{\text{Peak plate current} = 4.7}$
= 1276 ohms
Effective load, plate to plate = $4 \times 1305 = 5220$ ohms

Fig. 13—Chart Showing Calculation of Typical Operating Conditions for Class B Audio Amplifier

FOR CLASS B RADIO-FREQUENCY AMPLIFIERS

In Class B radio-frequency amplifier service, the radio-frequency current and voltage relations are as indicated in Fig. 14 below.

If the amplifier output is free from distortion, the plate voltage and plate current will vary linearly with the grid swing. Thus for a maximum modulation factor of 1.0 at the crest of the audio cycle the radio-frequency voltage and currents will be double those for the carrier conditions.

In calculating the performance of the Class B radio-frequency amplifier, the operating line A-B, Fig. 15, must be established by the following steps:

(1) Point A depends upon the value of d-c plate voltage and grid bias chosen. The higher the plate voltage the greater the power capa-

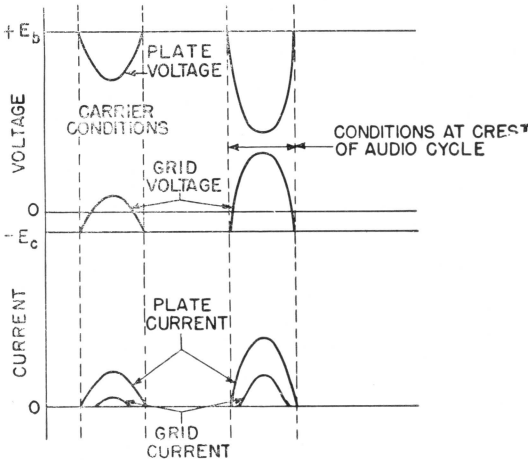


Fig. 14—Instantaneous Radio-frequency Voltage and Current Relations

1-2-46

bilities of the tube. The grid bias voltage is such as to allow a zero signal plate current of 10 to 15 per cent of the average d-c plate current under carrier conditions. The same factors apply as explained under Class B audio service. In the curve, Fig. 15, the point A is located at a plate voltage of 7500 volts, and a grid voltage of -300 volts.

(2) The location of point B depends upon a number of considerations. If it approaches too close to the diode line the grid drive and distortion are likely to become excessive for maximum modulation. If B is located too high in the positive grid region the grid drive would be increased at maximum modulation. It is usually necessary to make several sets of calculations to determine the optimum conditions for minimum distortion at the desired power output and maximum efficiency. Taking the above factors into account the point B for the curve on Fig. 15 was located at a plate voltage of 2500 volts and a grid voltage of 700 volts.

As in the case of the Class C oscillator the operating line on Fig. 15 is a straight line connecting points A and B.

Calculations for maximum modulation conditions will then be identical to those described for Class C operation, operating over the entire line from A to B.

Under carrier conditions, the tube operates over the same line, but the grid and plate swing are only one half that for maximum modulation. Therefore, for carrier conditions, calculations similar to those for maximum modulation are made, but the operating line extends only from A to C. Maximum plate dissipation occurs under carrier conditions so the value of dissipation calculated should be checked to see that the maximum ratings are not exceeded.

It is advisable to plot the rms value of the plate current versus the grid voltage for the conditions chosen for maximum modulation and to analyze the current wave for excessive distortion.

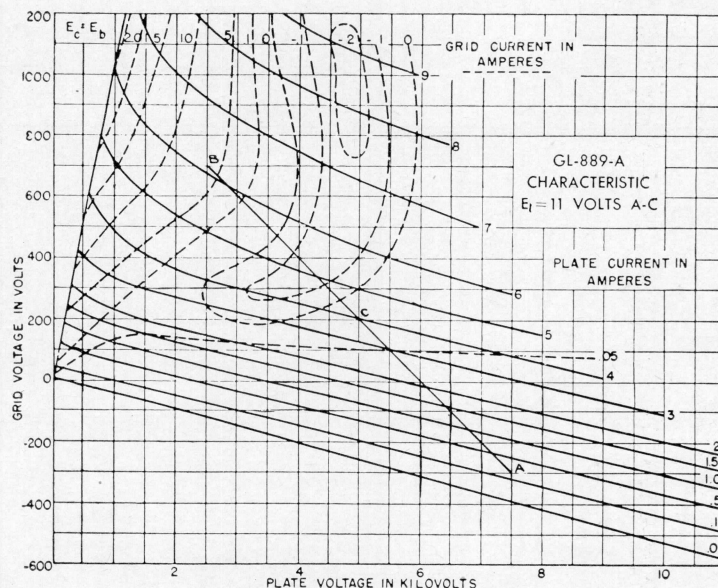


Fig. 15—GL-889-A Characteristic Curves with A-C-B Line

APPLICATIONS

General

Although the number and variety of tube types presented in this manual may seem somewhat bewildering at first glance, the selection of the most suitable tubes for a specific application is not difficult. The "Quick Selection Chart," included in the manual, provides a breakdown of tube types by method of cooling and maximum power input at various frequencies. Correlating

design considerations such as size, cost, and mobility must be taken into account, but are too varied and complex for treatment here.

A number of circuits are included to cover typical installations for rectifiers, oscillators, multipliers, and power amplifiers. Each circuit represents only one of the many accepted approaches to the problem involved, and is intended only as a guide to the designer.

Circuits shown in ETX-108 are examples of possible tube applications and the description and illustration of them does not convey to the purchaser of tubes any license under patent rights of General Electric Company.

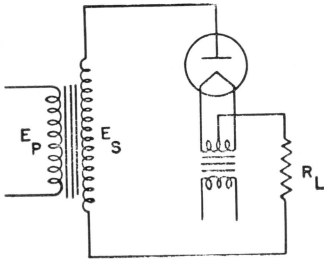
APPLICATIONS (CONT'D)

Rectifiers

The switching action of the simple diode is most widely used in power supplies. Fig. 16 and Figs. 17 through 26, illustrate some of the most popular rectifier circuits with companion wave forms, and the accompanying table on page 18 provides useful conversion ratios.

The single-phase, half-wave rectifier, Fig. 16, has the obvious advantages of simplicity and low cost. However, these gains may be materially reduced by the increased cost of filter components resulting from the comparatively low fundamental ripple frequency, and the ten-

dency of the transformer core to saturate due to the unidirectional current flow in its secondary.

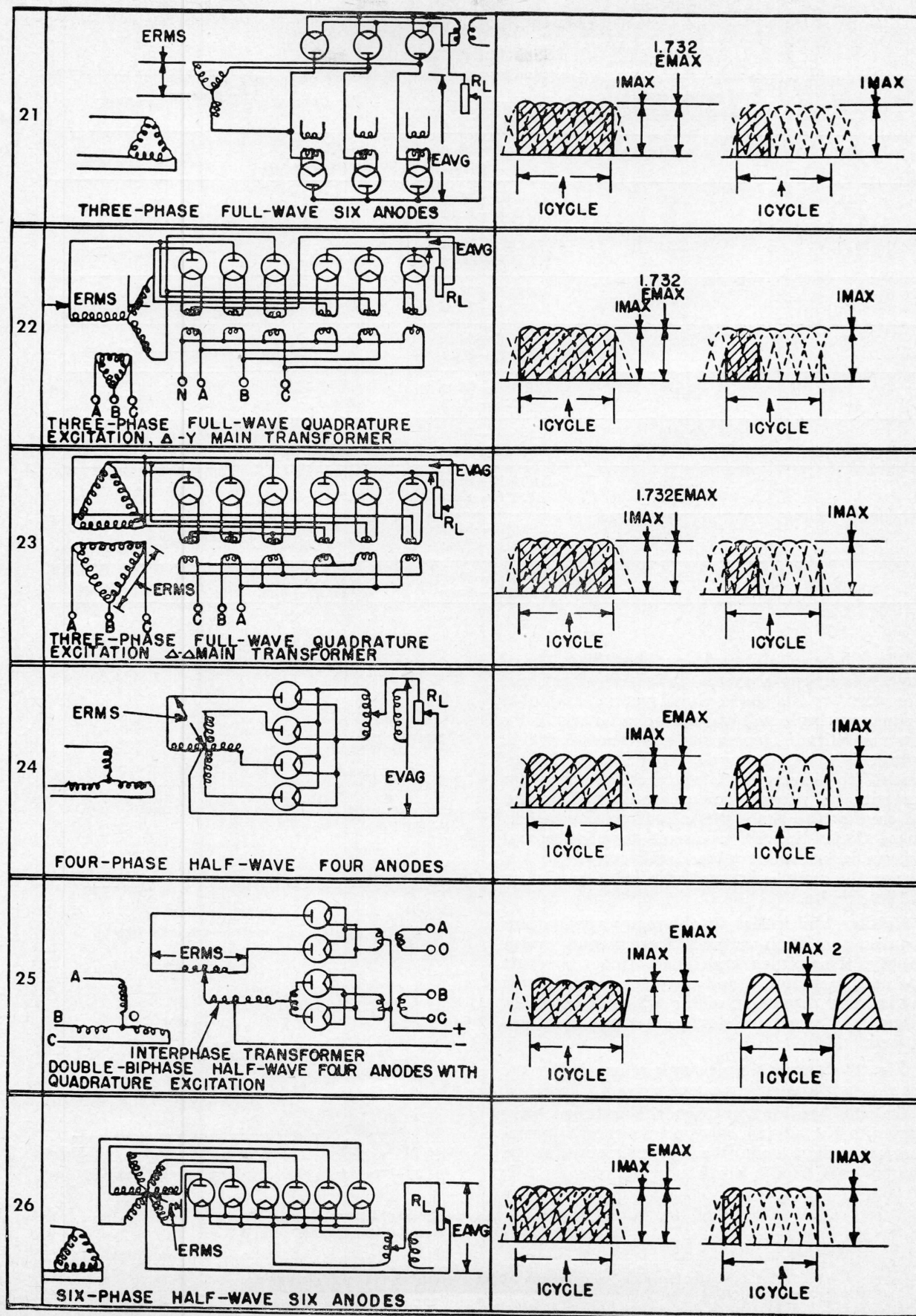


K-9186003 12-7-45
Fig. 16—Single-phase, Half-wave Rectifier

FIGURE	WAVE FORM
17 BIPHASE HALF-WAVE TWO ANODES	LOAD CURRENT TUBE CURRENT ICycle
18 BIPHASE FULL-WAVE FOUR ANODES	LOAD CURRENT TUBE CURRENT ICycle
19 THREE-PHASE HALF-WAVE THREE ANODES	LOAD CURRENT TUBE CURRENT ICycle
20 DOUBLE THREE-PHASE HALF-WAVE WITH INTERPHASE TRANSFORMER SIX ANODES	LOAD CURRENT TUBE CURRENT ICycle

Figs. 17 through 26

Circuits shown in ETX-108 are examples of possible tube applications and the description and illustration of them does not convey to the purchaser of tubes any license under patent rights of General Electric Company.



APPLICATIONS (CONT'D)
USEFUL RATIOS

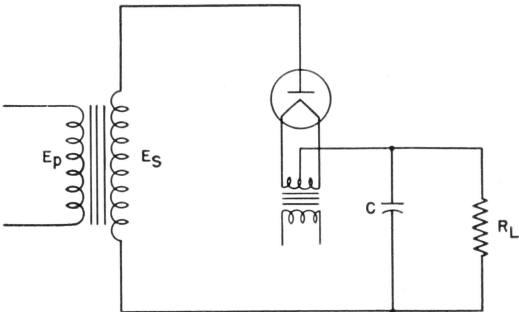
Fig. No.	Tube 1 (Avg.) Load 1 (Avg.)	E—Avg.	E—Inverse	I—Avg.
17	0.500	0.318 E—Max 0.450 E—Rms	E—Max 3.140 E—Avg.	0.636 I—Max
18	0.500	0.636 E—Max 0.900 E—Rms	E—Max 1.570 E—Avg.	0.636 I—Max
19	0.333	0.827 E—Max 1.170 E—Rms	$\sqrt{3}$ E—Max 2.090 E—Avg.	0.827 I—Max
20	0.167	0.827 E—Max 1.170 E—Rms	$\sqrt{3}$ E—Max 2.090 E—Avg.	0.827 I—Max
21	0.333	1.650 E—Max 2.340 E—Rms	$\sqrt{3}$ E—Max 1.050 E—Avg.	0.955 I—Max
22	0.333	1.650 E—Max 2.340 E—Rms	$\sqrt{3}$ E—Max 1.050 E—Avg.	0.955 I—Max
23	0.333	0.955 E—Max 1.340 E—Rms	E—Max 1.050 E—Avg.	0.955 I—Max
24	0.250	0.900 E—Max 1.274 E—Rms	2.220 E—Avg.	0.900 I—Max
25	0.250	0.318 E—Max 0.450 E—Rms	3.140 E—Avg.	0.318 I—Max
26	0.167	0.955 E—Max 1.350 E—Rms	2.090 E—Avg.	0.955 I—Max

The biphas half-wave rectifier, Fig. 17, of page 16 is a popular system in most applications. Compared to the single-phase system, its double frequency ripple voltage, with characteristically lower amplitude, represents the more desirable approach to power-supply design. Supplies intended to deliver high voltages at very low currents, i.e. peak rectifiers, are exceptions and do employ the single-phase half-wave rectifier. Inspection of the various circuit wave forms, and the table of ratios above, will convey to the reader the complexity and applicability of each of the circuits.

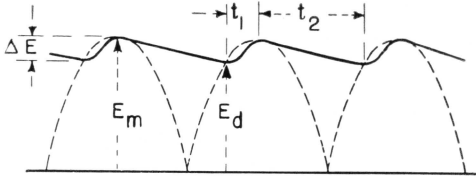
Voltage Multipliers: In the many applications requiring a high-voltage, low-current power supply, the voltage multiplier often represents the most economical and compact design. Some preliminary discussion of the action of capacitor filters will serve to clarify the principles involved.

Fig. 27 shows a simple single-phase, half-wave rectifier with capacitor output.

On the assumption that the voltage wave shown in Fig. 28 is a sawtooth (a good approximation at light loads) it may be shown that the fundamental ripple amplitude approaches ΔE ,



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Fig. 27—Single-phase, Half-wave Rectifier with Capacitor Output



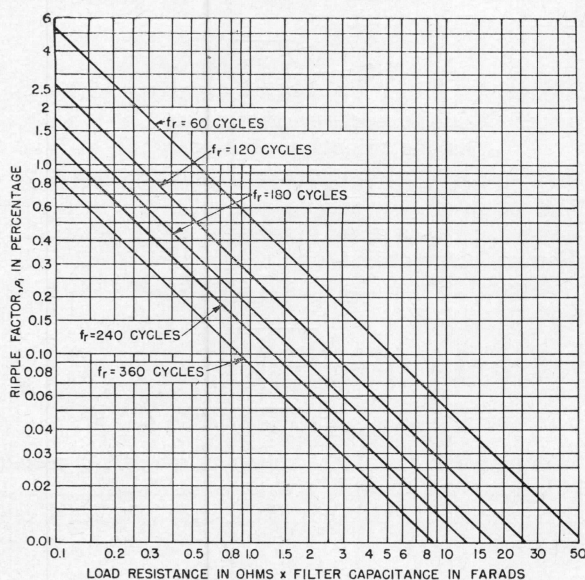
K-9186005 12-7-45
Fig. 28—Wave Form of the Capacitor Voltage under Light Load

where ΔE is the total voltage excursion, and that the ripple factor is P .

$$P = \frac{1}{\pi f R C}$$

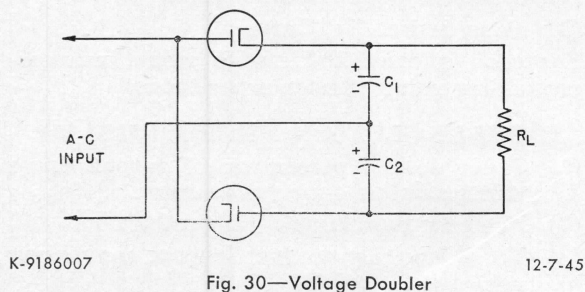
The expression, under the assumptions made, is valid only when p is small, at most a few per cent.

At heavy loads, the problem can be solved by a series of successive approximations, but the process is fairly tedious. Fig. 29, graphically representing the expected ripple factor for a number of resistance-capacitance combinations at various frequencies, can be used both for the simple single-phase half-wave supply and for the more complex multipliers.



K-9186006 12-7-45
Fig. 29—Ripple Factor for Resistance Load Shunted by a Capacitor

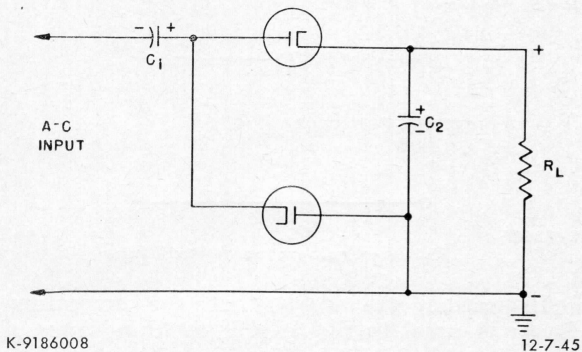
A form of voltage doubler is shown in Fig. 30. Its operation depends on the ability of the circuit to charge each of two capacitors in series to the peak voltage of the transformer. On the half cycle when point A goes positive C_1 is charged to full transformer voltage (less tube drop). C_2 charges on the alternate half cycle and the output voltage across R_L thus becomes



K-9186007 12-7-45
Fig. 30—Voltage Doubler

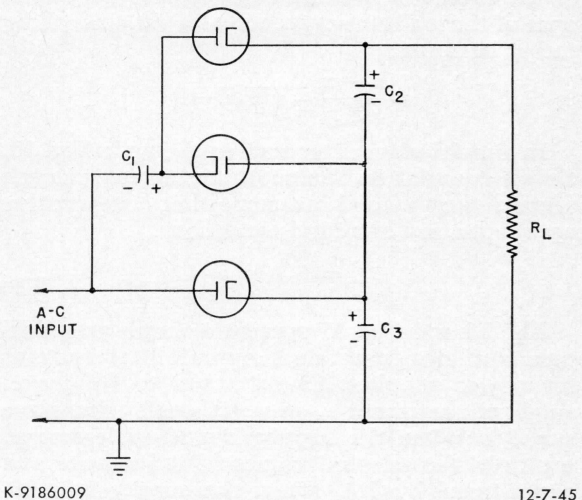
the instantaneous sum of the two capacitor voltages. Obviously the fundamental ripple frequency has become twice the line frequency of the input transformer.

Fig. 31 is another form of the doubler which allows grounding one end of the transformer secondary.



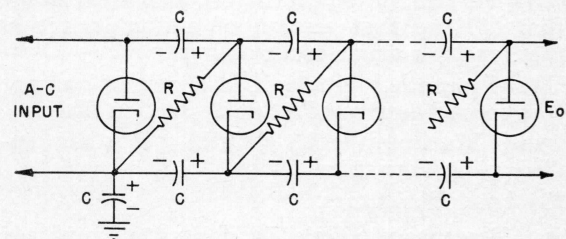
K-9186008 12-7-45
Fig. 31—Voltage Doubler for Grounded Input

Fig. 32 shows an extension of the doubler system to provide a d-c voltage almost equal to three times the peak transformer voltage.



K-9186009 12-7-45
Fig. 32—Voltage Tripler

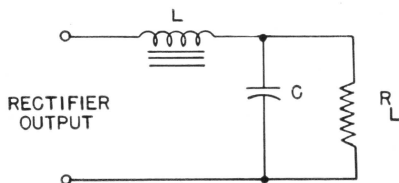
An interesting multiplier is shown in Fig. 33. It is especially adaptable to high-frequency rectifiers.



K-9186010 12-7-45
Fig. 33—Voltage Multiplier

APPLICATIONS (CONT'D)

Filters for Rectifiers: The single-section inverted L filter shown in Fig. 34 is subject to simple analysis. The standard definition of ripple factor is taken to be the ratio of the rms value of the ripple voltage to the algebraic average value of the total voltage, expressed in percentage.



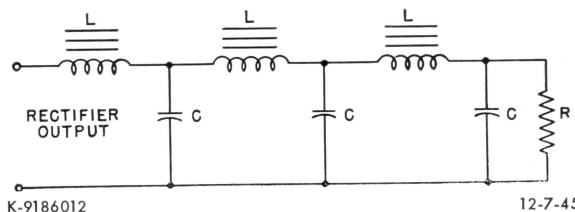
K-9186011

Fig. 34—Single-section Inverted L Filter

Inspection will show that the smoothing factor is equal to the total input impedance of the filter divided by the impedance of the capacitor and load resistance in parallel. In a well designed choke, the resistance of the choke is inconsequential compared to the reactance and, with the further assumption that the reactance of the capacitor is small compared to the resistance of the load, the expression for the smoothing factor becomes:

$$= \frac{X_L - X_C}{X_C} = W^2 LC - 1$$

In a multi-stage filter such as shown in Fig. 35, simple cumulation of smoothing factors for each section gives a good but somewhat conservative approximation of actual conditions.



K-9186012

Fig. 35—Multi-stage Filter

12-7-45

Since it may be shown that for a given total amount of capacitance and reactance, maximum filtering is achieved when all sections are alike, a working formula for the design of rectifier filters may be taken as

$$LC = \frac{\sqrt[n]{\mathcal{L} + 1}}{40 f_r^2 1}$$

where N is the number of sections

$\mathcal{L}$ is the smoothing factor

f_r is the fundamental ripple frequency

The value of $\mathcal{L}$ is simply the ratio of the input ripple factor, as determined from Fig. 29, to the desired factor at the load.

The relative values of L and C for optimum performance are:

$$C = \frac{\sqrt[n]{1 + \sqrt[n]{\mathcal{L}}}}{2 \pi f_r R}$$

$$L = R \sqrt[n]{1 + \sqrt[n]{\mathcal{L}}}$$

Precaution should be taken to avoid LC combinations which will resonate at fundamental or harmonic frequencies of the supply voltage or load.

Filter Charts

Fig. 36 and Fig. 37 present a simple graphical means of designing choke input filter systems for power supplies. These apply to full-wave, single-phase circuits only (60-cycle sine-wave supply). When the supply is a 50-cycle source, multiply the selected values of inductance and capacitance by 1.2. When the supply is a 25-cycle source, multiply the filter values by 2.4.

Erms = Maximum volts (RMS) per plate applied to rectifier tube.

RL = Load Resistance.

ER₁ = Percentage ripple in d-c output voltage from (1) the first section of a double-section filter, or (2) a single-section filter.

ER₂ = Percentage ripple in d-c output voltage from second section of a double-section filter.

Erms = Maximum volts (RMS) per plate applied to rectifier tube.

RL = Load Resistance.

ER₁ = Percentage ripple in d-c output voltage from (1) the first section of a double-section filter, or (2) a single-section filter.

Er₂ = Percentage ripple in d-c output voltage from second section of a double-section filter.

General Rules for Selection of Filter Constants

SINGLE-SECTION FILTER (FIG. 36)

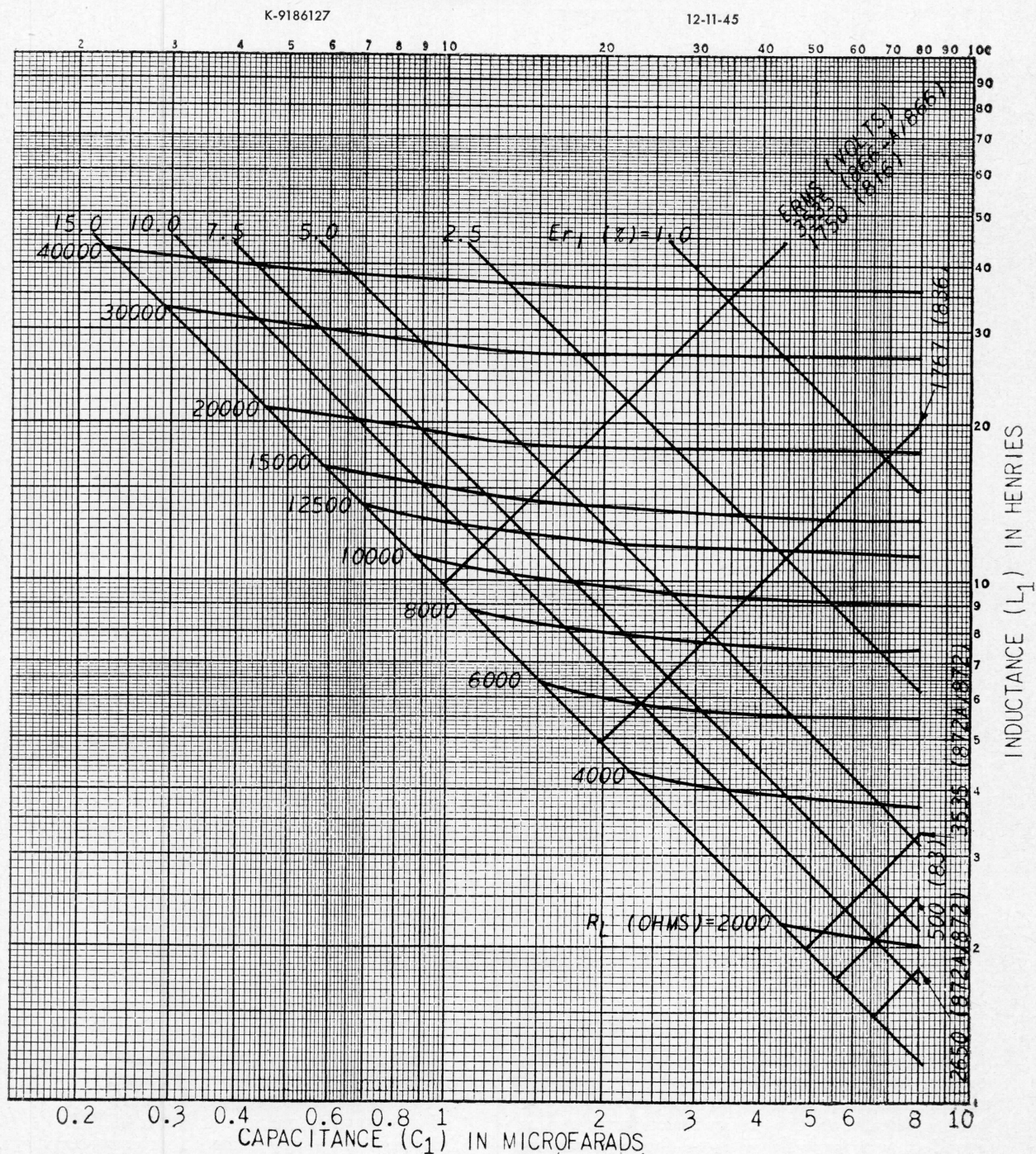
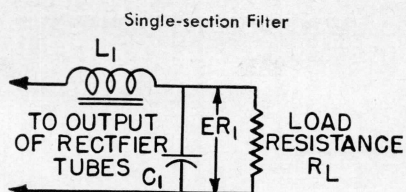
Select Inductance Values

- (1) above proper RI Curve
- (2) to left of proper ERMS Curve
- (3) along desired ER₁ Curve

For each selected inductance value, use corresponding value of filter capacitance.

DOUBLE-SECTION FILTER (FIG. 37)

- (1) Select desired percentage of output ripple voltage ER₂ on appropriate curve of ER₁.
- (2) Read corresponding L₂ C₂ product.
- (3) To satisfy this product, choose convenient values of L₂ and C₂.
- (4) Check value of selected L₂ to make sure that it is greater than $3(C_1 + C_2) + 2C_1 C_2$.



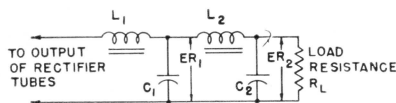
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Fig. 36—Design Chart for Single-section Filter

12-10 45

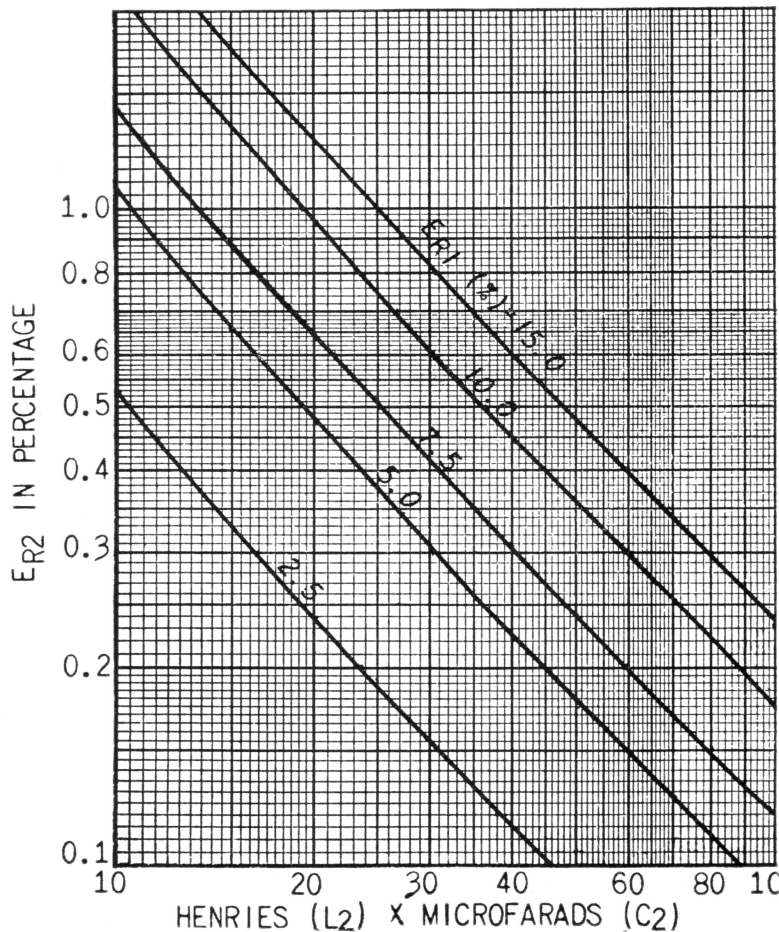
APPLICATIONS (CONT'D)

Double-section Filter



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Fig. 37—Design Chart for Double-section Filter

Selection of Tubes for Rectifiers

In general, the choice of tubes for rectifier service is based on the voltage and current requirements of the load circuit. For high current applications, the gaseous rectifier is recommended, and, for high voltages, the high vacuum rectifier is most desirable. The following points should be considered in the selection:

1. Output voltage required at load.
2. Average current required at load.
3. Peak inverse voltage on rectifier.
4. Peak rectifier current at full load.
5. Effects of nearby fields on gaseous rectifiers.
6. Effects of high-frequency transients generated by gaseous rectifiers.

AMPLIFIER AND OSCILLATOR CIRCUITS

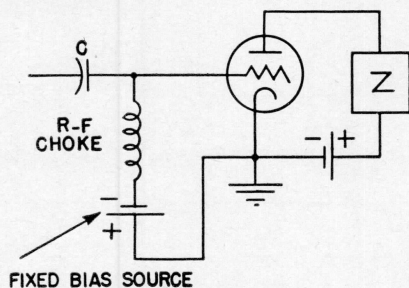
Five important factors are involved in the design of amplifiers and oscillator circuits for radio frequencies:

1. Grid Bias
2. Tank Circuits
3. Interstage Coupling
4. Neutralizing
5. Output Coupling

These, modified by considerations such as power supply capabilities, power output, power sensitivity, frequency range, space limitations, and cost, are the governing parameters the designer must consider.

1. Grid Bias—Three basic methods of obtaining grid bias are in common use, and it is important to understand the nature and capabilities of each, since they are not universally applicable.

Fig. 38 illustrates a simple amplifier employing fixed bias. An inductance-capacitance filter is sometimes used to block radio frequency from the bias supply, although it must be carefully designed and placed to avoid parasitic oscillations. An important advantage of the fixed bias system is the protection it offers to circuit and tubes against excessive current in cases where excitation fails.

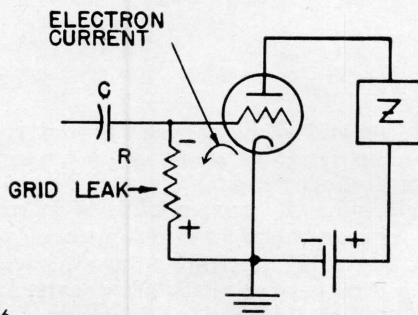


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Fig. 38—Amplifier Employing Fixed Bias

12-7-45

Fig. 39 shows an amplifier with grid-leak resistor bias. Bias is developed across the grid resistor by the diode action of the grid and cathode, and is proportional to the excitation voltage. Investigation of the biasing action indicates that the value of the grid resistor is not critical, and that it may be determined from the characteristic data by Ohm's Law.



K-9186016

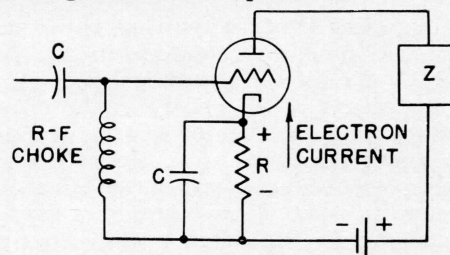
Fig. 39—Amplifier Employing Grid-leak Resistor Bias

12-7-45

The grid-leak bias generator has important applications in d-c transmission systems where a fixed reference level must be maintained, although the principle is generally modified to include a separate diode bias generator.

The advantages of simplicity are offset by the inability of the system to protect itself against loss of excitation and the resultant excessive plate current. Some over-current protection must, therefore, be included.

Fig. 40 represents a self-biased amplifier. Here, bias is developed across the cathode resistor by the flow of total tube current. The action of the capacitor prevents signal degeneration; it must be large enough to provide, with the cathode resistor, a time constant considerably longer than the period of the lowest frequency to be amplified. Since it is basically a degenerative bias, the self-bias system automatically protects the tube against destructive current overloads. Two disadvantages are evident: first, the effective plate voltage is lowered by the magnitude of the bias developed, necessitating a more generous power supply, and, second, the value and physical size of the by-pass capacitor must be fairly large to maintain gain at low frequencies.



K-9186017

Fig. 40—Amplifier Employing Self-bias

12-7-45

Very often, combinations of all three bias schemes are used and compensation for the individual disadvantages of each is achieved.

2. Design of Tank Circuits. The design of tuned circuits for radio-frequency amplifiers and oscillators can be a very complex problem. The wealth of experience, however, which has been gained from many years of radio development has established many simplifications and shortcuts which the circuit designer may employ.

No sharp dividing line is drawn between frequencies at which lumped circuit parameters can be successfully employed and those at which effective design becomes critically dependent upon the use of cavities, tuned lines, wave guides, etc. The change starts somewhere between 150 and 200 megacycles and is fairly complete above 500 megacycles. This section will be concerned with the first group and a later section, ETX-110, will cover the high-frequency problems.

The resonant frequency of a parallel tank circuit is variously given as:

1. The frequency for which the amplitude of the impedance is maximum.

AMPLIFIER AND OSCILLATOR CIRCUITS (CONT'D)

2. The frequency for which the power factor is unity.
3. The frequency for which the power absorbed is minimum for given impressed voltage.
4. The frequency (or frequencies) which occur in the circuit in transient response, i.e., the "natural" frequencies.

The fact that these frequencies differ is primarily based on variations in the types of parallel circuits under consideration. For our purposes, however, frequency differences are so slight (less than 1 per cent), that any definition will suffice. Using the unity power factor relation then:

$$X_L = X_C$$

$$\text{or } f = \frac{10^3}{2\pi(LC)^{1/2}}$$

where,

f is the frequency in megacycles,

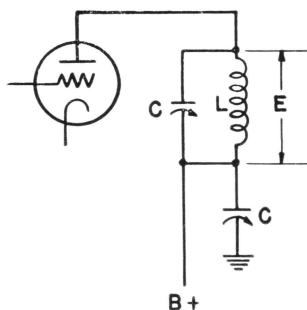
L the inductance in microhenries,

C the capacitance in micromicrofarads.

The operating Q of a circuit is defined as the ratio of the tank volt-amperes to the power supplied to the circuit by the tube. It is, in a sense, a measure of the ability of the resonant circuit to sustain itself. At low Q's the generation of harmonics is severe, and, since these harmonics represent unused power, the efficiency of the system is poor. These harmonics may also be responsible for interference with other radio services if they are radiated and should be minimized on this account.

Too high an operating Q results in excessive losses in the tank due to the large circulating current, and, therefore, needless expenditure of power. A Q between 10 and 15, generally 4π , is used as the design figure.

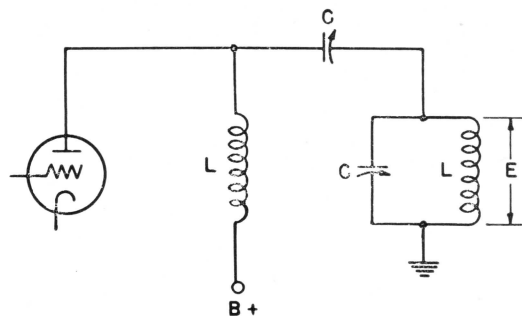
Fig. 41, 42, 43 and 44 illustrates a number of common tank circuits. The voltage E is the radio-frequency voltage developed to ground and is approximately equal to the plate voltage.



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Fig. 41—Tank Circuit with Series Feed

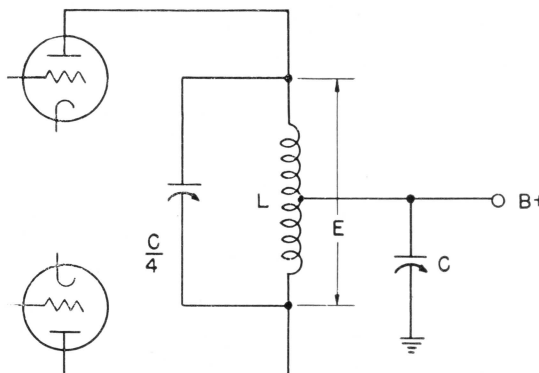
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K-9186019

Fig. 42—Tank Circuit with Shunt Feed

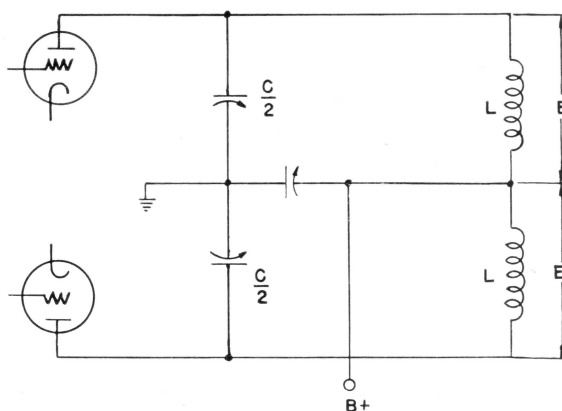
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Fig. 43—Push-Pull Tank Circuit with Series Feed, Single Stator

12-7-45



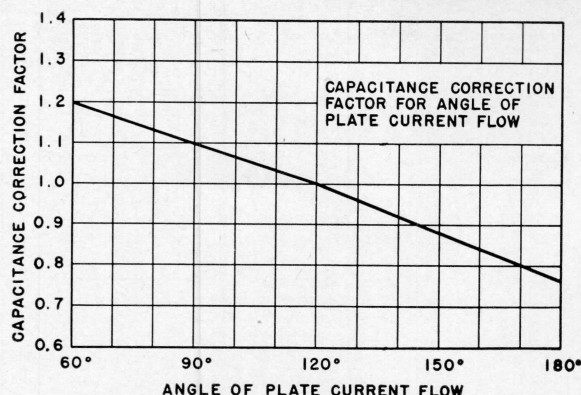
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Fig. 44—Push-Pull Tank Circuit with Series Feed, Split Stator

12-7-45

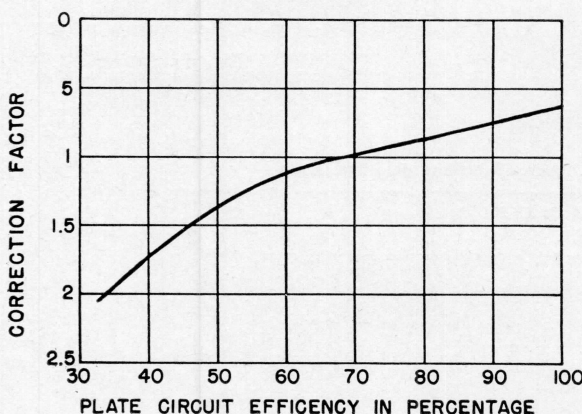
Fig. 45, 46 and 47 may be used for determining the optimum design capacitance for a number of operating frequencies and Q's and Figs. 48 and 49 to determine the proper value of inductance for the chosen frequency. Allowances of the order of five to 50 micromicrofarads should be made for the various distributed capacitances which will be encountered in the circuit.

AMPLIFIER AND OSCILLATOR CIRCUITS (CONT'D)



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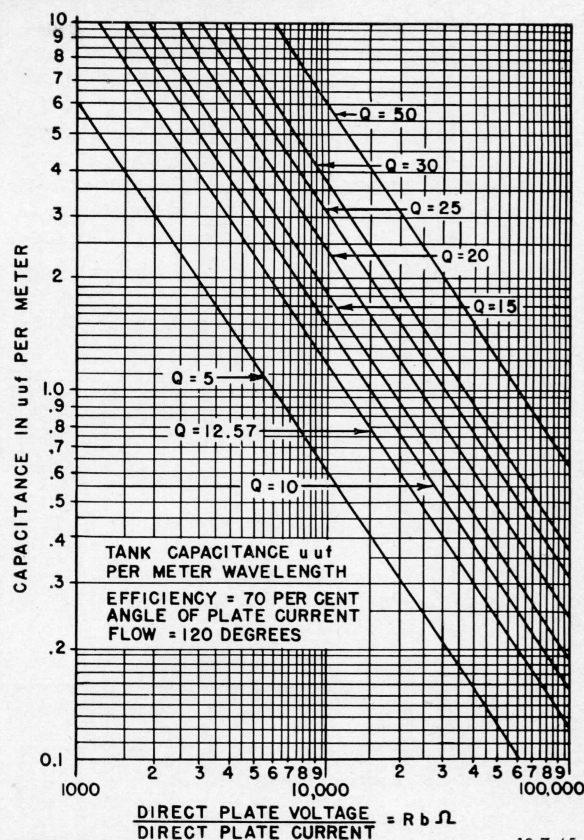
Fig. 45—Correction Factor by which Capacitance of Fig. 47 Should be Multiplied for Angles of Current Flow Different from 70 Per Cent



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Fig. 46—Multiply Capacitance Value from Fig. 47 by Correction Factor from this Chart if Efficiency of Plate Circuit is Different from 70 Per Cent

Fig. 45 and 46—Batcher and Moulis; *Electronic Engineering Handbook*, p-216; Electronic Development Associates (O. H. Caldwell, M. Clements); 1944



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Fig. 47—Tank Capacitance Calculator for Class C Amplifiers. Capacitance value is to be multiplied by operating wavelength in meters. Q value is for fully loaded operation and is usually 4 or 12.57. Use Fig. 45 and Fig. 46 to correct for other angles of current flow and circuit efficiency. The circuit resistance scale R_b is in ohms

Fig. 47—Batcher and Moulis; *Electronic Engineering Handbook*, p-215; Electronic Development Associates (O. H. Caldwell, M. Clements); 1944

HOW TO USE CHARTS OF FIG. 48 AND 49

Use of Figure 48:

The chart of Fig. 48 may be used to find:

- (1) The reactance of a given inductance at a given frequency.
- (2) The reactance of a given capacitance at a given frequency.
- (3) The resonant frequency of a given inductance and capacitance.

In order to facilitate the determination of magnitude of the quantities involved to two or three significant figures the chart is divided into two parts. Fig. 48 is the complete chart to be used for rough calculations. Fig. 49, which is a single decade of Fig. 48, enlarged approximately 7 times, is to be used where the significant two or three figures are to be determined.

To Find Reactance

Enter the charts vertically from the bottom (frequency) and along the lines slanting upward

to the left (capacitance) or to the right (inductance). Corresponding scales (upper or lower) must be used throughout. Project horizontally to the left from the intersection and read reactance.

To Find Resonant Frequency

Enter the slanting lines for the given inductance and capacitance. Project downward from their intersection and read resonant frequency from the bottom scale. Corresponding scales (upper or lower) must be used throughout.

Example: The sample point indicated (Fig. 48) corresponds to a frequency of about 700 kilocycles and an inductance of 0.5 henry, or a capacitance of 0.1 micromicrofarad, giving in either case a reactance of about 2,000,000 ohms. The resonant frequency of a circuit containing these values of inductance and capacitance is, of course, 700 kilocycles, approximately.

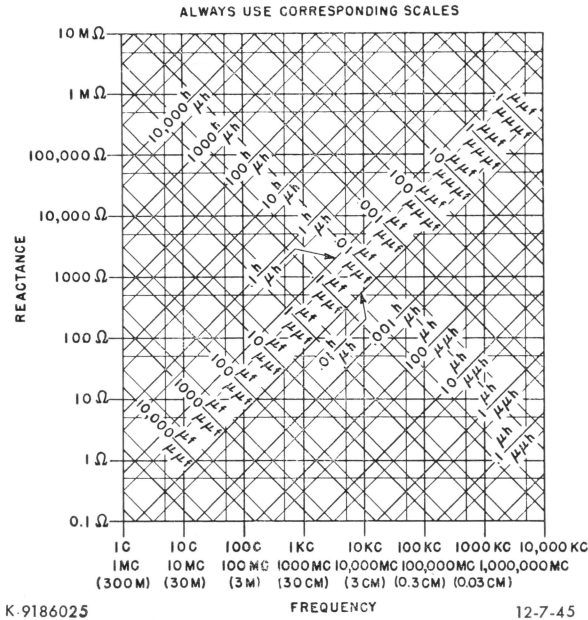
AMPLIFIER AND OSCILLATOR CIRCUITS (CONT'D)

Use of Figure 49

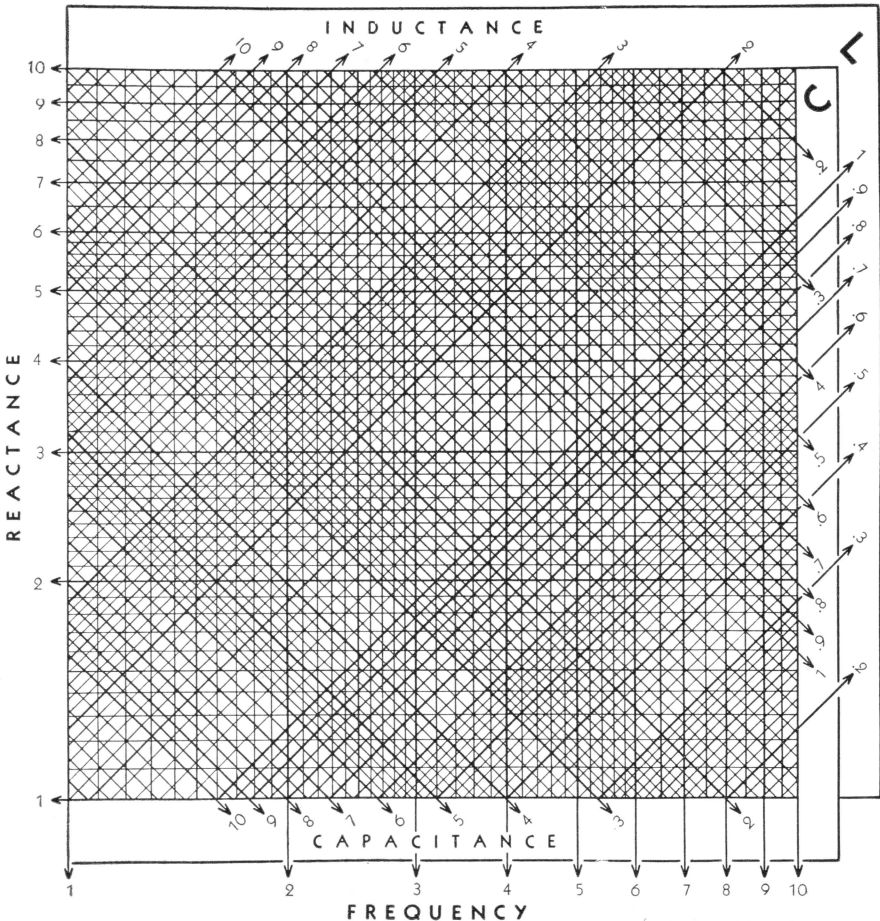
Fig. 49 is used to obtain additional precision of reading but does not place the decimal point which must be located from a preliminary entry in Fig. 48. Since the chart necessarily requires two logarithmic decades for inductance and capacitance for every single decade of frequency and reactance, unless the correct decade for L and C is chosen, the calculated values of reactance and frequency will be in error by a factor of 3.16.

Example: (continued) The reactance corresponding to 0.5 henry or 0.1 micromicrofarad is 2,230,000 ohms at 712 kilocycles, their resonant frequency.

†† Fig. 48—Reactance Chart →



Always obtain approximate value from Figure 48 before using Figure 49



†† Fig. 49—Inductance—Capacitance Chart

†† Fig. 48 and 49. Courtesy of General Radio Company

AMPLIFIER AND OSCILLATOR CIRCUITS (CONT'D)

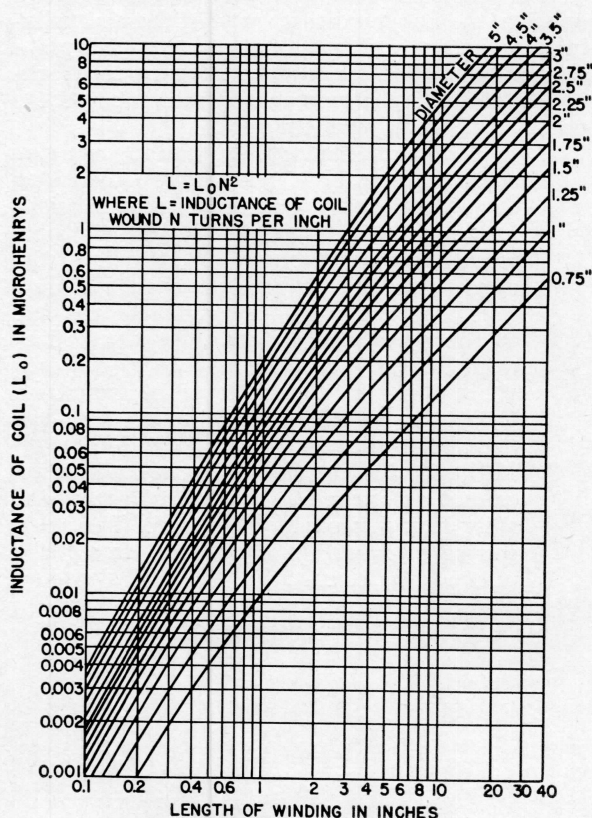
Tank Inductance

The design of the tank inductance can be carried out with the aid of Fig. 50. From the desired inductance, L , the value of L_0 is determined by:

$$L_0 = \frac{L}{N^2}$$

where N is the number of turns per inch to be used. The winding length, s , is established from the graph and the total number of turns is simply the product, Ns . Fig. 50 may also be used for the inverse operation, i.e., determining the inductance from the dimensions of a given coil.

It is important to remember that coupling circuits will, in general, have important effects on the apparent capacitance and inductance of a circuit and these effects must be included in the tank circuit design calculations.



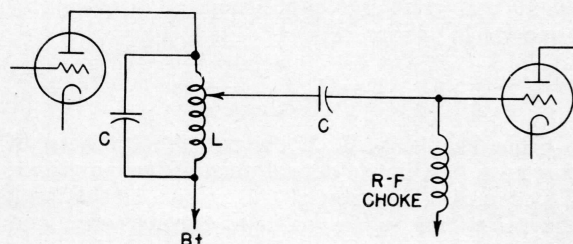
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Fig. 50—Inductance of Coils Wound One Turn per Inch (from Nagaoka's Formula)

3. Interstage Coupling. Interstage coupling in radio-frequency amplifiers may be effected by either capacitive or inductive coupling. In capacitive coupling, energy is fed from one stage

to another through a d-c blocking capacitor. As shown in Fig. 51, the coupling can be made a fraction of the total output of the first stage by tapping the plate tank. The circuit has the advantage of simplicity, but may be the cause of spurious resonances.

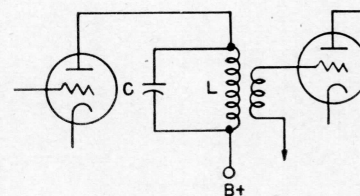


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Fig. 51—Amplifier with Capacitive Coupling

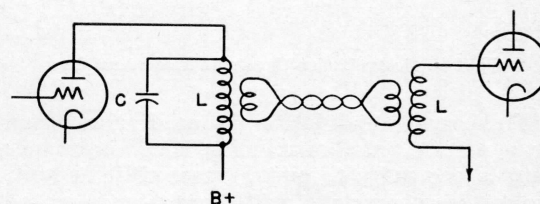
Inductive coupling (Fig. 52 and Fig. 53) may be either direct, or through transmission lines. If direct coupling is used, mechanical problems may result from the necessity of maintaining short leads. Transmission lines, such as the link coupling, allow reasonable separation of components. The link consists of a twisted pair terminated at each end by a few turns inductively coupled to the plate and grid tanks. For maximum transfer of energy the coils must be placed at the current maxima of the tanks. Other forms of inductive couplings, parallel lines, coaxial lines, etc. are practical and often used.



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Fig. 52—Amplifier with Direct Inductive Coupling



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Fig. 53—Amplifier with Link Inductive Coupling

AMPLIFIER AND OSCILLATOR CIRCUITS (CONT'D)

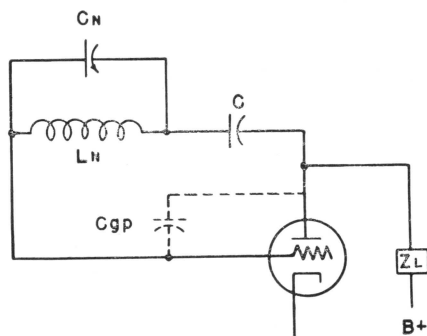
4. Neutralizing. One of the most serious problems encountered in the design of radio-frequency amplifiers employing triodes is the capacitive feedback of energy from plate to grid. It may be shown that the effect of this feedback is to increase tremendously the apparent input capacitance of the system. At optimum tuning, when the grid and plate voltage are exactly opposite in phase,

$$C_i = C_{gp} \left(1 + \frac{E_p}{E_g} \right)$$

Since the ratio, E_p/E_g , is not simply the μ of the tube, but is the actual gain of the amplifier, C becomes a function of the nature of the load, the tube bias, plate voltage, tuning, etc., and subject to so many variables that it becomes difficult to predict or control.

With a triode, no possible method of avoiding feedback exists, and neutralization must be used. This is accomplished by applying, to the grid circuit, a current equal in magnitude and opposite in phase to that flowing through C_{gp} .

An interesting form of neutralization is shown in Fig. 54. The circuit is adjusted so that the inductance reactance of L_n is equal to the capacitive reactance of C_{gp} and C_n together. Although L_n could be made adjustable to equal C_{gp} , variable reactors are difficult to build, and by making L_n slightly larger than needed, the easily controlled C_n can be added. Since the circuit formed by L_n and $C_{gp} + C_n$ are in resonance, the impedance is very nearly a maximum and the grid-plate current circulates only in the loop.

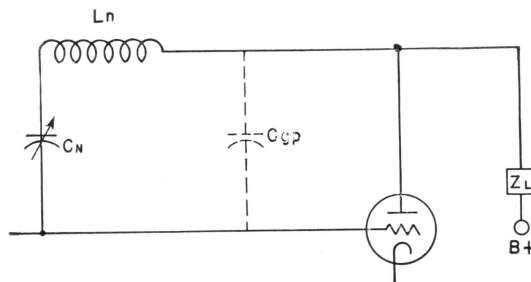


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Fig. 54—Neutralization Circuit for Triode Amplifier

When grid modulation is used, the circuit arrangement is as shown in Fig. 55. This arrangement is necessary to avoid phase shift at audio frequencies across the grid circuit but does not provide neutralization as good as the first circuit.



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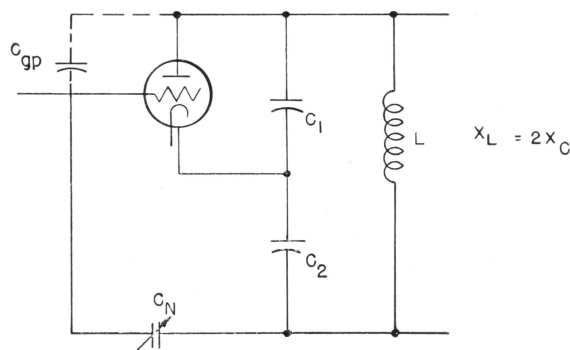
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Fig. 55—Neutralization for Circuit with Grid Modulation

A widely used neutralization is the so-called "built-out" circuit. The neutralizing current is fed back from a point having a voltage opposite in phase to the anode voltage, and the built-out circuit produces this voltage.

It is convenient to have this voltage roughly equal to the anode voltage, so that the neutralizing capacitor can be equal to the grid-plate capacitance. The circuit often takes the form of Fig. 56. It is important to remember these points concerning this circuit:

1. The currents through C_{gp} and C_n are not equal under ideal operating conditions since the voltage across C_{gp} is the arithmetic sum of the grid and plate voltage, while the voltage across C_n is their arithmetic difference. The components of current that are equal and opposite are due to the plate, the criterion for neutralization, but the components due to the grid are in phase, so that the input is capacitive.
2. C_2 acts in parallel with C_n to produce the total built-out reactance.
3. If the load is coupled to L , neutralization cannot be complete because of the phase shift introduced by the load. The load coupling must be separate from the neutralizing circuit.



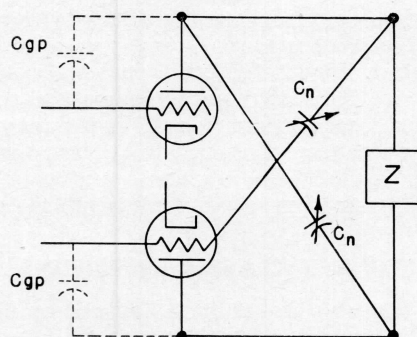
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Fig. 56—Built-out Neutralization Circuit

AMPLIFIER AND OSCILLATOR CIRCUITS (CONT'D)

It is apparent that neutralization is most easily accomplished with push-pull circuits. Here, the out-of-phase voltages are ready and waiting. A simple criss-cross network is added as in Fig. 57.

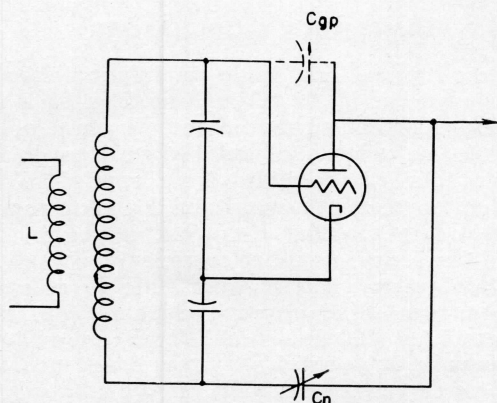


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Fig. 57—Criss-Cross Neutralization Circuit

The circuits shown in Fig. 58 and Fig. 59 have been used, but, while they give some of the desired effects during adjustment, they do not produce true neutralization. Ordinarily, excitation is applied with the plate voltage removed and C_n adjusted to give a minimum on a radio-frequency indicator. A good null is obtained when C_n is equal to C_{gp} . If, however, we consider an r-f voltage on the anode of Fig. 58, it is apparent that while this voltage will cause equal and opposite currents to flow through the capacitors, no net current flows in the grid inductance. The currents produce voltages across the grid capacitors which are in phase with the plate voltage. Since this is in phase opposition to the grid excitation, negative feedback is produced.

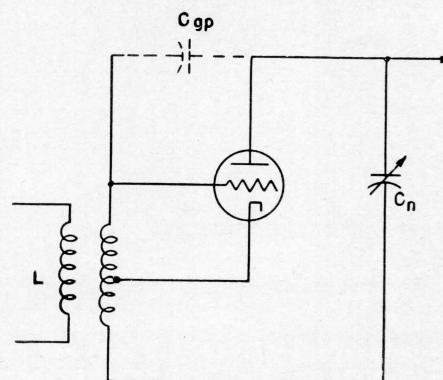


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12-7-45

Fig. 58—Imperfect Neutralization Circuit

On the build-out, the excitation voltage and feedback voltage are in phase. The apparent null indicates neutralization only so long as the system is in balance.



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12-7-45

Fig. 59—Another Circuit Employing Imperfect Neutralization

Two more circuits are shown in Fig. 60 and Fig. 61. Instead of a built-out circuit, phase reversal is obtained by using a transformer. Using the legend shown in the figure, the following relations may be used for the design:

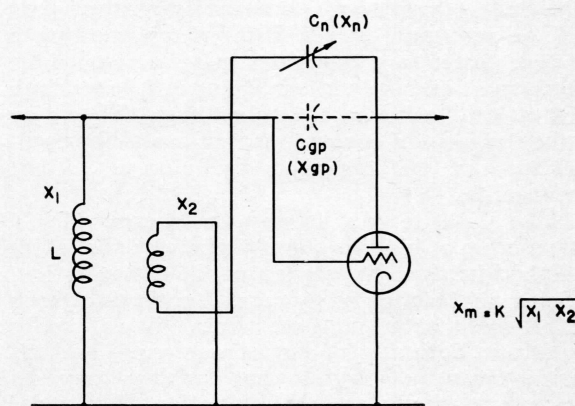
$$\frac{X_n}{X_{gp}} = \frac{K\sqrt{X_2 X_1}}{1 - \frac{X_2}{X_n}(1 - K^2)}$$

If $X_n \gg X_2$ or if the coefficient of coupling approaches unity

$$\frac{X_n}{X_{gp}} = K\sqrt{\frac{X_2}{X_1}}$$

If $C_n = C_{gp}$, then

$$\frac{X_2}{X_1} = \frac{1}{K^2}$$



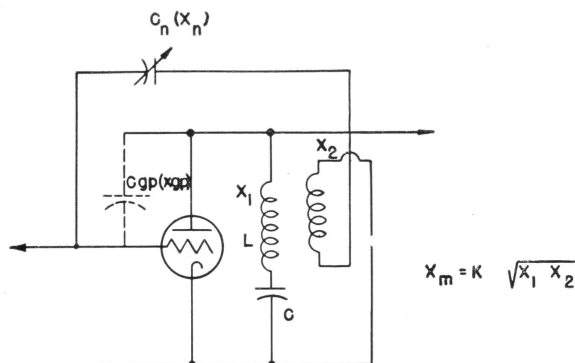
K-9186036

12-7-45

Fig. 60—Hazeltine Grid-neutralization Circuit

$$X_m = K\sqrt{X_1 X_2}$$

Amplifier and Oscillator Circuits (Cont'd)



K-9186037

12-7-45

Fig. 61—Hazeltine Plate-neutralization Circuit

5. Output Coupling. The problems involved in coupling an amplifier to a load such as an antenna are very similar to those of interstage coupling. Capacitive coupling can be used but is useless in the suppression of harmonics. Inductive coupling reduces the transfer of harmonics to the antenna and effectively isolates the load from the high d-c voltages of the final amplifier, and allows the use of transmission lines.

PARASITIC AND TUNING CONSIDERATIONS

Parasitic oscillations are a frequent and occasionally serious problem in the design of both audio and radio-frequency amplifiers. Although a good deal can be done to eliminate them in the design program, they sometimes appear in even the most carefully designed circuits.

Parasitics generally occur at frequencies somewhat higher than the operating frequency and without necessarily integral relation to that frequency. They are caused by various circuit components which in combination satisfy the conditions required for oscillation. As a rule, the tube capacitances form an important part of the resonant circuit. Besides representing a severe power loss, parasitics may be responsible for erratic and even intermittent operation, high distortion, flashover, and tube failure. They may take the form of continuous, self-sustained oscillations, or be triggered by various circuit transients.

The parasite can usually be located with a neon lamp or high frequency receiver; the latter method helps to fix the frequency of oscillation. Cures can be effected by careful analysis or by a trial and error method. Pass filters, series resistors, detuning of parasitic circuit, and rearrangement of layout and wiring may be necessary, singly or in combination. The series

resistors should be placed so as to present a severe load to the parasite circuit and little load to the amplifier itself. In parallel tube operation, series resistors isolating the tube grids and, possibly, low resistance radio-frequency chokes should be included as a matter of course in the design.

Multiple radio-frequency grounds should be avoided and the utmost simplicity maintained in the layout. Shunt fed grid and plate supplies should not be used together since the complex resonant combinations which result may cause serious parasiting. Tuning and loading taps, long leads, crowding of components and poor power supply filtering may also cause trouble.

TUNING CLASS C AMPLIFIERS

The first step in tuning a Class C amplifier is to obtain proper neutralization. Adjustment of the neutralizing circuit is made without plate voltage on the tube by applying grid excitation, and tuning for minimum radio-frequency voltage between plate and ground or minimum radio-frequency current in one of the output circuit elements. Another method is to adjust the neutralizing circuit so that no change in d-c grid current occurs as the plate circuit is tuned through its range. In low power amplifiers, a neon lamp near the plate circuit is an effective null indicator. If the load causes detuning of the circuit, the tank must be re-trimmed during the process.

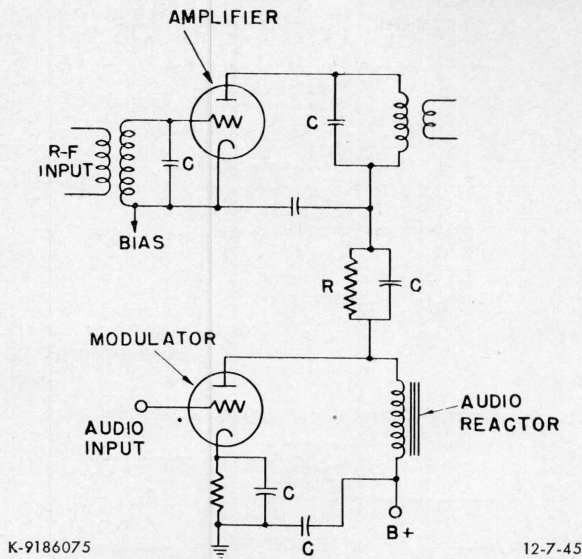
The grid circuit is tuned to resonance as indicated by maximum grid current. If the rectified current is less than that recommended for the tube, the excitation, should be increased.

It is important to remember that the tuning of an amplifier is a step by step process, and that any one adjustment may entail resetting of other circuit components.

AMPLITUDE MODULATORS

Some typical amplitude modulation circuits are shown in Fig. 62 through 66. Fig. 62 is the Heising constant-current circuit for plate modulation. The polarity of induced voltages in the reactor due to the audio drive applied to the modulator tends to maintain constant supply current. As modulator current increases, the radio-frequency amplifier current drops and the radio-frequency carrier amplitude is reduced. The purpose of the dropping resistor R is to limit the amplifier voltage so that 100 per cent modulation can be achieved. C serves as low-impedance by-pass capacitor around R for the audio-signal current.

AMPLITUDE MODULATORS (CONT'D)

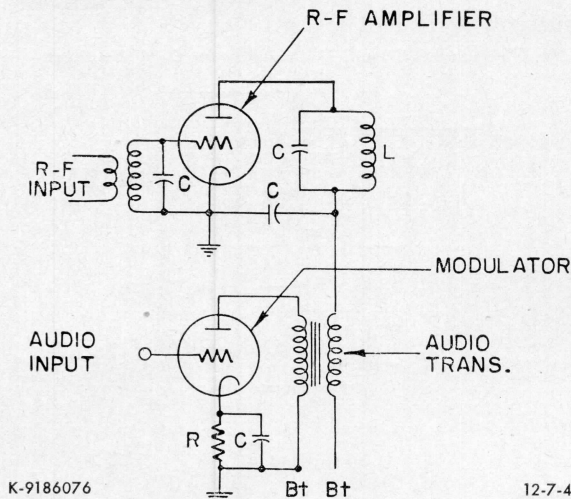


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Fig. 62—Heising Constant Current Circuit for Plate Modulation

Fig. 63 employs a transformer rather than a reactor. It may be driven by a Class A, Class B, or Class AB amplifier. The audio signal is superimposed upon the plate supply as a series voltage. When the impedances of the modulator and radio-frequency tube plate circuits are properly matched, 100 per cent modulation with low distortion can be accomplished.



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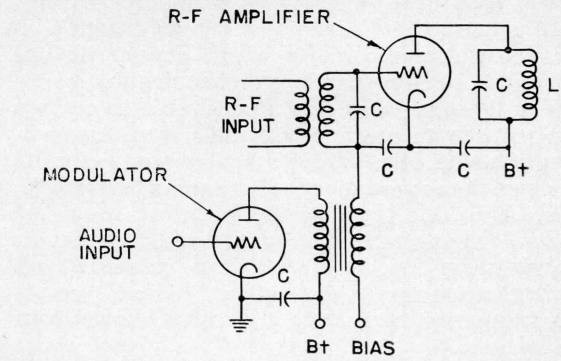
12-7-45

Fig. 63—Modulator Employing Transformer

Fig. 64 shows a grid modulation circuit. The bias of the radio-frequency amplifier is varied at the audio rate with consequent variation in the radio-frequency envelope. The advantage of the system is that it takes very little audio driving power, but, since operating conditions must be carefully chosen and maintained, the circuit is difficult to use.

Suppressor modulation, Fig. 65, involves the introduction of the audio component in series with the suppressor bias. As with grid modulation,

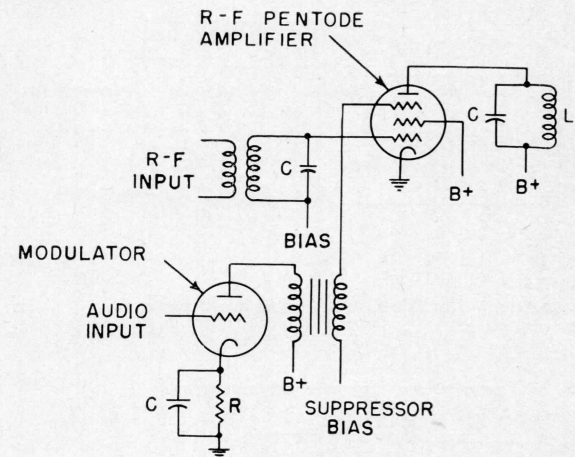
tion, driving power is small, but the circuit is critical and tends to distort at high modulation levels.



K-9186077

Fig. 64—Grid-modulation Circuit

12-7-45

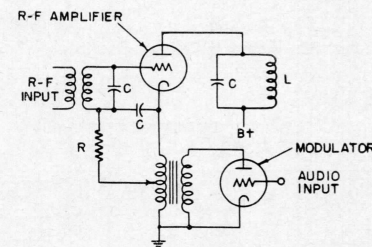


K-9186078

Fig. 65—Suppressor-modulation Circuit

12-7-45

The cathode modulator, shown in Fig. 66, gives a combination of both grid and plate modulation since both the effective grid bias and the plate voltage are varied. The amount of grid modulation is generally kept small to improve carrier efficiency by adjustment of the grid leak resistance and positioning of the grid return on the tapped secondary of the modulation transformer.



K-9186079

Fig. 66—Cathode-modulation Circuit

12-7-45

In general, the plate modulated amplifier provides the highest operating efficiency, about 70 to 80 per cent. Grid modulated stages rarely have efficiencies greater than about 35 per cent. The cathode-modulated amplifier, since it represents a combination of plate and grid modulation, normally is operated at about 55 per cent.

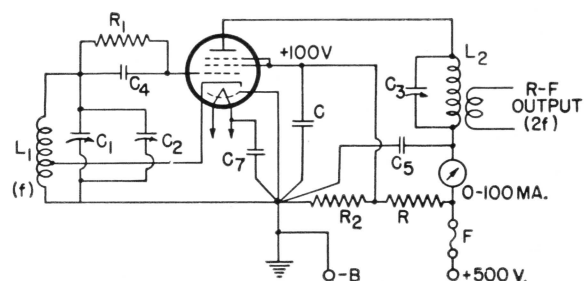
TYPICAL CIRCUITS

Fig. 67 through 73 shown on this page are selected to illustrate a few circuits commonly used in typical transmitting applications.

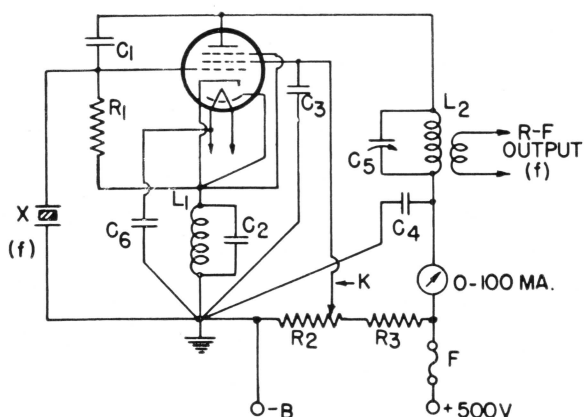
In general the diagrams of Fig. 67 through 73 are conventional circuits which experience has proven to be dependable and practicable.

The designer may find it desirable in certain applications to use a part of one circuit in combination with other circuits or portions of circuits to meet the requirements of a particular design.

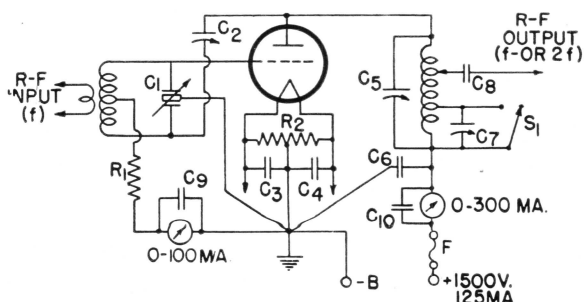
Specific tube type numbers are not indicated on the diagrams as the choice of a particular transmitting triode, tetrode or pentode will depend upon the power output desired, operating frequency, size, cost and other design considerations.



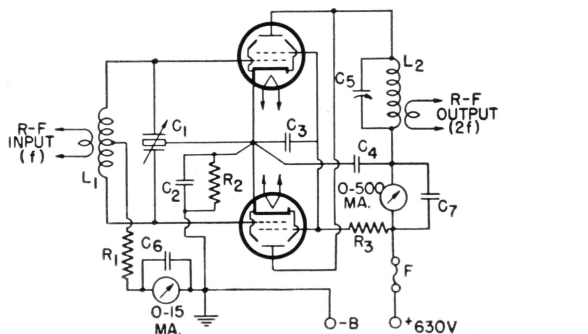
K-9186149 Fig. 67—Electron-Coupled Oscillator 1-9-46



K-9186146 Fig. 68—Reinartz Crystal Oscillator 1-9-46

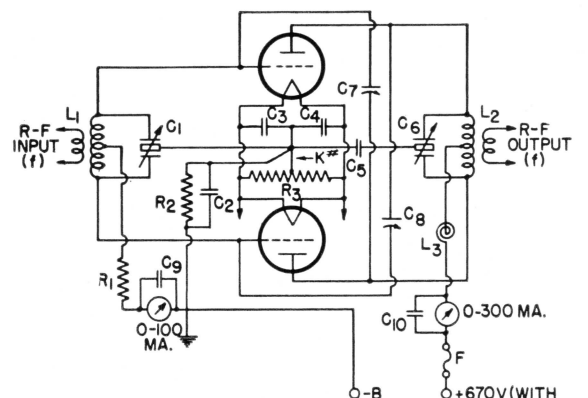


K-9186148 Fig. 69—Frequency Doubler or R-F Power Amplifier (Class C) 1-9-46
Telegraphy)



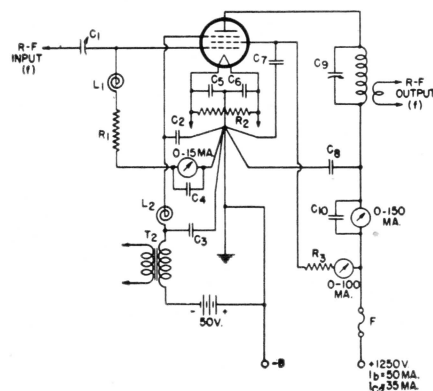
K-9186144 (WITH CATHODE BIAS) 1-9-46

Fig. 70—Push-Pull Frequency Doubler of High Efficiency



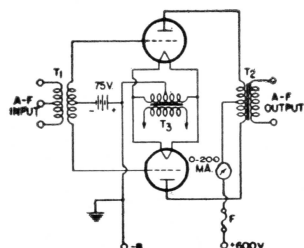
K-9186147 (WITH CATHODE BIAS) 1-9-46

Fig. 71—Push-Pull Class C R-F Amplifier for C-W Telegraphy



K-9186143 1-9-46

Fig. 72—Suppressor-modulated Pentode R-F Power Amplifier



K-9186145 1-9-46

Fig. 73—Class B Modulator

INSTALLATION AND OPERATION CONVECTION-COOLED TYPES

INSTALLATION

Mechanical

Mountings must be of good quality and should be so installed as to minimize danger from impact. If the set is subject to vibration, a shock-absorbing suspension must be employed.

Cooling

All apparatus should be arranged to allow free circulation of air around the tube. The bulb becomes very hot during operation and, therefore, should neither come in contact with any metallic object nor be subjected to drops or spray of liquid.

Sets using more than one tube should provide adequate spacing between tubes so that adjacent portions of the bulbs do not operate appreciably hotter than the other sections.

Electrical

To avoid danger of corona discharge, all wires and connections should be made to allow several inches of free space around the tube. For tubes using a metal base, the metal shell must not be connected to any part of the circuit.

The filament should be operated preferably from an a-c source, although a d-c supply may be used. The filament voltmeter should be connected to indicate the voltage at the filament terminals. The filament supply should be designed to allow operation at rated filament voltage. The filament transformer shall have good regulation and should be designed for at least thirty per cent above rated filament wattage.

Thoriated-tungsten filaments should be operated at eighty per cent of normal filament voltage during stand-by periods of less than two hours and shut down entirely for longer periods. However, for small tubes of less than 250 watts plate dissipation rating the filament voltage may be removed for stand-by periods greater than 15 minutes. There should be no reduction of filament voltage for periods of less than five minutes. The filament voltage may be reduced to eighty per cent during periods greater than five minutes if desired.

Oxide-coated filaments or cathode heaters should be operated at normal filament voltage during stand-by periods. If the stand-by periods exceed two hours the filament current may be shut off.

Overheating by severe overload may decrease filament emission. Unless the overload has liberated a large amount of gas, the activity of the filament usually can be restored by operating the filament at rated voltage for ten minutes or more with no voltage on the plate or grid. This process may be accelerated by increasing the filament voltage to 20 per cent above the normal value (not higher) for a few minutes.

The grid-circuit and plate-circuit return leads should be connected to the center tap of the filament-transformer secondary. When d-c filament excitation is used, the return leads from the grid and plate circuits should be connected to the negative filament terminal.

The circuits should be arranged to prevent parasitic oscillations so that the tube will not be subjected to excessive voltages and current.

An ammeter in the plate circuit of each tube should be connected so that the direct-plate current may be checked regularly.

The plate circuit should be provided with a protective device such as a fuse or relay in order to prevent overheating caused by improper circuit adjustments or overloading. This device should remove the plate voltage instantly if the direct-plate current reaches a value 50 per cent above normal.

In rating transmitting tubes, certain values are given as maximum; that is, the values beyond which it is unsafe to go from the viewpoint of life and performance. In order not to exceed the maximum ratings, changes in plate and filament voltage caused by line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus must be determined. Then, an average value of plate voltage should be chosen so that under the usual operating conditions the maximum ratings will not be exceeded.

IN TRYING OUT A NEW CIRCUIT OR WHEN ADJUSTMENTS ARE BEING MADE, THE PLATE VOLTAGE SHOULD BE REDUCED IN ORDER TO PREVENT DAMAGE TO THE TUBE OR ASSOCIATED APPARATUS IN CASE THE ADJUSTMENTS ARE INCORRECT.

OPERATION

General

Maximum ratings and typical operating conditions for each recommended class of service are given on the Description and Rating Sheet covering the individual type of tube. The typical values given must not be considered as ratings, because the tube may be used at any suitable conditions within the maximum ratings.

Class A Audio-frequency Amplifier or Modulator

Grid bias for this type of service may be obtained from a separate voltage source or by means of a self-biasing resistor shunted by a filter network to avoid degenerative effects at the low audio-frequencies. When several tubes are operated in parallel, it is necessary to make provision for individual adjustment of grid bias to insure that the plate dissipation of any tube does not exceed the maximum value. This may be accomplished by means of a tapped C battery or, if self bias is used, by means of a variable cathode resistor for each tube. When the self-

INSTALLATION AND OPERATION (CONT'D)

biasing method is used, separate filament supplies are necessary for each tube.

An output device such as a choke or transformer should be used to transfer power efficiently from the tube to the load.

Class B Audio-frequency Power Amplifier or Modulator

In this type of service two tubes are used in a "balanced" circuit, each tube conducting only half the time. The plate loss becomes maximum at a signal slightly less than 1, depending on the circuit conditions, and therefore the plate dissipation must be limited so that at this value of sustained signal, the plate loss will not exceed the maximum rating.

The input transformer should be designed to give good frequency response when operated into an open circuit, such as that represented by the grid circuit of the Class B stage when the signal amplitude is small. It should be designed also to handle the required input power for maximum signal conditions.

The output transformer should be designed so that the resistance presented by the load is reflected as the proper plate-to-plate loading in the Class B stage. For example, if the load is a modulated Class C amplifier operating at 2000 volts and 500 milliamperes, the ratio of the output transformer to provide a plate-to-plate loading of 10,000 ohms would be $10000 \div 4000$, or 1.58 to 1, step-down. The transformer should be designed with a core large enough to avoid saturation effects, which would impair the quality of the output. If the secondary is to carry the direct plate current of the modulated amplifier, the core should be made larger and should include an air gap.

Class B Radio-frequency Amplifier

In Class B radio-frequency service, the plate is supplied with unmodulated direct voltage, and the grid is excited by modulated r-f voltage. It is important to note that in this service the plate dissipation is greatest when the carrier is unmodulated. Therefore, the circuit should be adjusted so that, without modulation, the plate loss will not exceed the maximum rating.

Grid bias for Class B a-f or r-f service should be obtained from a battery or other d-c source of good regulation. It should not be obtained from a high-resistance supply such as a grid leak.

Class C Radio-frequency Power Amplifier Plate Modulator

In this type of service, the plate supply voltage is modulated so that the tube output is modulated radio frequency. Assuming a value, P , of plate input to be modulated, the amount of audio-frequency power to be supplied is equal to $\frac{m^2 P}{2}$, where m is the modulation factor.

The maximum ratings and typical operating conditions given in the Technical Information are such that a modulation factor up to 1.0 may be used. When a lower value of modulation is used, the plate dissipation allowed may be increased, but should be limited so that with the modulation sustained at its peak value, m , the plate loss will not exceed a value $\frac{3}{2+m^2}$ times the plate dissipation rating.

Grid bias for this service may be obtained from a grid leak or from a combination of grid leak and generator, rectifier, or cathode-bias resistor, suitably by-passed for audio and radio frequencies. The combination method is desirable because distortion effects may be minimized.

Class C Radio-frequency Power Amplifier and Oscillator

In telegraph service, the plate input power is keyed, i.e., is on and off alternately in accordance with the characters of some code. During the key-down periods, the tube functions as an unmodulated radio-frequency power amplifier. The tube may be used also as an amplifier or oscillator without keying. In both types of service, the ratings given are for key-down conditions.

Certain methods of modulation may be applied to this class of service provided the modulation is essentially negative and the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

Grid bias for Class C service may be obtained from a grid leak, from a battery, from a rectifier of good regulation, or from a self-biasing resistor by-passed with a suitable capacitor. With the grid-leak method, the grid excitation must not be removed without also removing the plate voltage. Grid-bias values are not particularly critical, and correct circuit adjustment may be obtained with widely different values.

Note: The ratings and characteristics of a particular transmitting tube are given on the Description and Rating Sheet for that tube.

FORCED AIR-COOLED TYPES

INSTALLATION

Mechanical

The tube should be tested upon receipt in the equipment in which it is to be used. The glass bulb, and particularly the glass area around the base, should be free from foreign matter.

any foreign material may become charred and cause puncture of the bulb.

The standard mounting supports the tube in the correct vertical position with the glass end up. The tube must not be subjected to vibration or shock. It is advisable to secure the tube in its mounting location by means of a lock washer.

fore making the electrical connections. The grid and filament leads should not be taut, but should allow for some movement without placing a strain on the glass bulb. Before readjustment of the tube is made, the leads should be disconnected.

Cooling

The air-cooling system for the anode consists of a blower with a suitable air duct leading to the fin cooler of the tube. The air flow required is specified on the Description and Rating Sheet for each type. The temperature of the incoming air should not exceed 45 C.

Proper cooling must be provided to limit the glass temperature to not more than 150 C at the hottest point. Usually deflecting vanes diverting the outgoing air toward the terminal seals provide sufficient cooling. In some cases it may be necessary to provide a separate cooling system. This system may consist of a blower and an air duct of suitable cross-sectional area leading to a nozzle directing the air flow. For the 893A-R a nozzle is incorporated in the cathode base. The air flow required is specified on the Description and Rating Sheet for each type.

The cooling air must not contain any foreign matter. The air-cooling systems should be properly installed to insure safe operation of the tube under all conditions and for this reason should be electrically interconnected with the filament and plate supplies to prevent the application of voltages to the tube without suitable cooling. An air-flow interlock which removes the filament and plate power is necessary to protect the tube when the air flow is insufficient or ceases. Precautions should be taken to insulate the air-cooling system from the anode and grid.

Electrical

Suitable meters should be provided for reading filament voltage, plate voltage and current, and d-c grid current. A tube life recording meter (to read hours of operation) should also be provided.

The installation of all wires and connections must be made so that they do not lie on or close to the glass of the tube. Otherwise, severe trouble may arise from corona discharge or increased dielectric loss which will result in almost certain puncture.

The filament circuit carries a high current at low voltage. Therefore, precautions should be taken against loss of voltage and heating due to poor connections. The filament connectors particularly should be large and make good contact.

In the case of the 8002-R tube, three filament leads are brought out to terminals. These may be paralleled by capacitors to reduce the inductance of the filament circuit for the r-f returns. The filament sections must be operated in series from the filament supply. The center tap is to be used only for r-f or power supply returns.

The high initial rush of current through the filament when the switch is first closed should be limited by the use of some form of filament starter. This may be a system of time-delay relays cutting resistance out of the circuit, a high-reactance filament transformer, or a manual control. In any case, the starting current must never, even momentarily, exceed $1\frac{1}{2}$ times the normal value. Provision must be made also for accurate adjustment and maintenance of the filament voltage. The filament voltmeter should be connected to indicate the voltage at the filament terminals. The filament base should not be connected to ground or to any part of the circuit. Filament power may be alternating current or direct current. When alternating current is used, the plate and grid circuit returns should be made to the center point of the filament supply. When direct current is used, these returns should be made to the negative terminal.

For multiphase filament tubes it is essential that the connections for each type of filament voltage supply be made according to the circuit diagram to prevent distortion and possible failure of the filament.

The plate circuit should be provided with a time-delay relay to delay the application of plate voltage until the filament has reached at least eighty per cent of the normal voltage. It must be provided also with protective devices to prevent the tube from drawing a heavy overload. The coil of an instantaneous overload relay (set for slightly higher than normal plate current) placed in the ground lead of the plate return and operating to remove the plate voltage, may be used for this purpose. The total time required for the operation of the relay and breaker should be in the order of one-tenth second and not more than one-sixth second. Plate series protective resistors should also be provided to protect the tube from excessive energy dissipation during instantaneous failure of insulation, within the tube or within the transmitter. The minimum value of this resistor which will give adequate protection with minimum power loss is given on the Description and Rating Sheet. Precautions must be taken so that no high capacitance is connected directly across the tube in such a manner that a disturbance within the tube will discharge appreciable energy from the capacitor.

The grid circuit should be provided with heavy conductors, carefully connected, in order to prevent overheating of the grid terminal due to r-f currents.

In the 8002-R tube three grid leads are brought out to terminals. These may be used in parallel to reduce the inductance of the grid circuit. If desired, to reduce coupling, one lead may be used for the neutralizing circuit and the other two for the grid-excitation circuit. When the tube is used in an oscillator circuit at the higher frequencies, it may be necessary to

FORCED AIR-COOLED TYPES (CONT'D)

INSTALLATION (CONT'D)

neutralize the feedback partially in order to prevent excess grid excitation caused by the normal grid-plate capacitance.

If two or more tubes are used in the circuit, controls should be provided so that adjustment may be made to balance properly the plate current taken by each tube.

In Class B service, grid bias of excellent regulation is usually required.

In Class C service, the bias voltage may be supplied by a grid leak, or by a combination of grid leak and generator, grid leak and rectifier, or grid leak and cathode-bias resistor suitably by-passed. The combination method is particularly suitable to reduce distortion, especially in plate-modulated operation. Since the grid-bias voltage for Class C service is not particularly critical, correct circuit adjustment may be obtained with values differing widely from those indicated for this service.

The circuits should be arranged to prevent parasitic oscillations so that the tube will not be subjected to excessive voltages and currents.

OPERATION

When a new tube is first placed in operation, it should be operated without plate voltage for fifteen minutes at rated filament voltage. After this initial preheating schedule, plate voltage can be applied. Operate for fifteen minutes at approximately one-half the usual plate voltage. Full voltage may then be applied and the tube operated under the normal load conditions for a period of one hour or more. Every three months spare tubes should be given this preheating and initial operation schedule.

The filament should be operated at constant voltage rather than constant current and must be allowed to reach at least eighty per cent normal voltage before plate voltage is applied. Intermittent power supply interruptions may be allowed provided the time off does not exceed one second. If the tube is to be used at relatively low output, the plate current will be less than normal, requiring less than normal emission of the filament. The filament, therefore, may be operated at a voltage slightly lower than rated voltage, giving longer life. The permissible reduction in filament voltage may be checked by reducing the filament voltage with the transmitter under normal operation to a value where reduction in output or increase in distortion can just be detected. The filament voltage must then be increased by an amount equivalent to the maximum percentage regulation of the filament supply voltage. Care must be taken that sufficient emission is provided. Otherwise, instability of operation or excessive distortion may be experienced, or the rated plate dissipation of the tube may be exceeded. From the viewpoint of tube life, it is usually economically advantageous to provide good regulation of the

filament voltage. For example, if the filament is operated continuously at six per cent above normal voltage, the evaporation life will be reduced to approximately one half.

When a multiphase filament-supply voltage is used, the phase voltages must all balance within fifteen per cent during the filament starting period. During normal operation the phase voltages must never, even momentarily, exceed ten per cent unbalance.

If the apparatus in which the tube is used is to be idle for periods not exceeding two hours, voltage should be maintained on the filament. However, if desired, provision may be made to reduce the filament voltage to approximately eighty per cent of the rated value during the stand-by. Where stand-by periods exceed two hours the filament voltage may be removed.

When direct-current filament excitation is used, the filament leads should be reversed every five hundred hours of operation.

Maximum ratings and typical operating conditions for each recommended class of service are given on the Description and Rating Sheet. The amplifier classifications used are those given in the Report of the Standards Committee of the Institute of Radio Engineers.

The output values given in the tabulation on the Description and Rating Sheet are approximate tube outputs under certain typical operating conditions. These must not be used as output ratings; circuit losses must be subtracted from the tube output in calculating the useful output.

In determining the value of plate voltage for normal operation, the line voltage fluctuation, load variation, and manufacturing variations must be estimated so that the maximum rated values will not be exceeded.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced to approximately one-half the rated value to prevent damage to the tube or associated apparatus. After correct adjustment has been made with the tube operating smoothly and without excessive heating of the cooler or the glass bulb, the plate voltage may be raised in several steps to the desired value. Adjustments should be made at each step for optimum operation.

In case of overload and resultant overheating of the tube, the vacuum may be impaired. When the quantity of gas is not too great, the tube may be operated to bring about an electrical clean-up of the gas. The first step in the process should be a short period of operation at a plate voltage of one-half the normal value. The plate voltage should then be increased to the normal value and the tube allowed to operate for a period of one hour or more. In severe cases it may be possible to age the tube by operating with a series resistor in the plate supply. Short periods of operation may be conducted at each step as the resistor is reduced until stable operation at the normal plate voltage is obtained.

Mechanical

The handling of a transmitting tube requires care since a tube may be damaged if subjected to shock or vibration.

The tube should be tested upon receipt in the equipment in which it is to be used. The glass bulb, and particularly the glass area around the terminals, should be free from foreign matter. The leads become hot during operation so that any foreign material may become charred and cause puncture of the bulb.

The standard jacket supports the tube in the correct vertical position with the filament end up. The tube must not be subjected to vibration or shock.

The tube should be placed in its water jacket carefully, centered accurately, and then firmly fastened. Secure the tube in its jacket before making the electrical connections. When the jacket-clamping device is tightened, the contacts must seat properly on the tube flange. Proper seating in the jacket will be obtained by use of the standard gasket which is supplied with each tube. A new gasket must be used whenever a tube is placed in the jacket. It is recommended that the gasket be coated with a thin film of prodag to prevent sticking. The clamping device should first be tightened gently to prevent possible strain at the anode seal caused by improper seating of the flange. When this preliminary adjustment indicates the tube is seated properly, the jacket can be tightened securely. Do not tighten more than required to seat the anode flange properly on the gasket. If these precautions are not taken, the tube may be ruined by a glass crack caused by the uneven pressure on the flange. The grid and filament leads should not be taut, but should allow for some movement without placing a strain on the glass bulb. When electrical connections are made to the tube, care should be taken to exert as little bending movement as possible to the terminal pins. Before a readjustment of either the tube or its jacket is made, the leads should be disconnected. The retaining lugs, threads, and moving parts of the jacket may be kept free from rusting and sticking by coating them with a thin film of oil or oiltag. Do not use an adhesive to seal the jacket against leaks because any sticking of the anode in the jacket may cause the tube to be damaged during its removal.

The water-cooling system for the anode consists, in general, of a source of cooling water, a water jacket, and a feed-pipe system which carries the water to and from the jacket. When the anode is at a high potential above ground, the feed-pipe system should have good insulation qualities and proper design to reduce the leakage current to a negligible value.

An outlet water thermometer and a water flowmeter are advisable since water flow and

temperature are important. The water must not be allowed to boil and the flow must be great enough to prevent steam bubbles forming on the plate surface. The temperature of the water at the outlet must not exceed 70 C. Proper functioning of the water-cooling system is of the utmost importance. Even a momentary failure of the water flow will damage the tube. It is, therefore, necessary to provide a method for preventing operation of the tube during such a condition. This may be accomplished by the use of water-flow circuit breakers, or interlocks, which open the filament and plate power supplies whenever the flow is insufficient or ceases.

The cooling water should flow upward along the anode and the piping must be arranged to avoid air traps in the jacket. Excessive water hammer may develop peak water pressures sufficient to deform the anode. Therefore, the piping system must be installed and operated properly so that water hammer does not occur. The pressure in the jacket must not exceed 80 pounds per square inch. If necessary, relief valves should be installed to prevent excessive pressure. The rate of water flow given on the Description and Rating Sheet is usually sufficient for all types of service. Under abnormal conditions an increased rate of flow may be necessary to prevent overheating. The formation of steam may be detected by the use of an improvised stethoscope which may consist of six feet of insulating tubing with proper safety precautions. The stethoscope is pressed against the jacket at various points while suitable listening observations are made.

Distilled water is recommended for cooling because it greatly reduces the probability of scale formation on the anode during life. Scale hinders proper transfer of heat from the anode to the water. The mineral content, flow, heat dissipation, temperature, etc., of undistilled water are so varied that no specific recommendations to prevent scale can be made. A sample of the cooling water should be analyzed before plans are made for the water system. In general, water which shows a hardness greater than 10 grains per gallon should not be used. Regardless of the kind of water used, the system should be kept free from accumulation of foreign material. A 10 per cent solution of hydrochloric acid will ordinarily dissolve scale in emergency cases. After such treatment, the anode should be rinsed carefully. The tube must be removed from its jacket for this treatment and, since frequent removals are objectionable because of danger from accidental breakage, it is desirable to prevent the formation of scale.

When forced-air cooling is called for on the Description and Rating Sheet, a system should be used which consists of a blower with air

WATER-COOLED TYPES (CONT'D)

INSTALLATION (CONT'D)

ducts of proper cross-sectional area which supply air to suitable air nozzles. In certain of the larger tubes (such as the 862-A and the 898-A) both the bulb and the stem must be air cooled. In these tubes the nozzle which supplies air to the filament stem is incorporated in the base, and the nozzle which supplies air to the bulb is part of the water jacket and acts as a combination air nozzle and electrostatic shield.

Tubes which require forced-air cooling on the stem only have an air nozzle incorporated in the cathode base.

Where the air nozzle is not part of the base or water jacket and the grid and filament terminals and the bulb require air cooling, a nozzle should be provided as part of the air-cooling system to direct the cooling air toward the top portion of the bulb.

The system should be arranged so that the temperature of the glass is not more than 150 C at the hottest point. Even when forced-air cooling is not called for on the Description and Rating Sheet, free circulation of air must be provided to limit the temperature of the glass to this value. When there is inadequate ventilation or where a tube is used at the higher frequencies, forced-air cooling may be required. In such cases a small blower may be used with suitable nozzles directing the air to the areas where cooling is necessary.

The cooling air must not contain any foreign matter. The air-cooling system should be electrically interconnected with the filament and plate supplies to prevent the application of voltage to the tube without suitable cooling. Precautions should be taken to insulate the air-cooling system from the anode and grid.

Air and water cooling of the GL-862-A and -898-A must be continued for ten minutes after power has been removed. For all other types water cooling only must be continued for two minutes after shutdown.

Electrical

Suitable meters should be provided for reading filament voltage, plate voltage, and current, and d-c grid current. A tube life recording meter (to read hours of operation) should also be provided.

The installation of all wires and connections must be made so that they do not lie on or close to the glass of the tube. Otherwise, severe trouble may arise from corona discharge or increased dielectric loss which will result in almost certain puncture.

The filament circuit carries a high current at low voltage. Therefore, the usual precautions should be taken against loss of voltage and heating due to poor connections. The filament con-

In the case of the 8002 tube, three filament leads are brought out to terminals. These may be paralleled by capacitors to reduce the inductance of the filament circuit for the r-f returns. The filament sections must be operated in series from the filament supply. The center tap is to be used only for r-f or power supply returns.

The high initial rush of current through the filament when the switch is first closed should be limited by the use of some form of filament starter. This may be a system of time-delay relays cutting resistance out of the circuit or high-reactance filament transformer or a manual control. In any case, the starting current must never, even momentarily, exceed $1\frac{1}{2}$ times the normal value. Provision must be made also for accurate adjustment and maintenance of the filament voltage. The filament voltmeter should be connected to indicate the voltage at the filament terminals. The filament base should not be connected to ground or to any part of the circuit. Filament power may be alternating current or direct current. When alternating current is used, the plate and grid circuit returns should be made to the center point of the filament supply. When direct current is used, these returns should be made to the negative terminal.

For multiphase filament tubes it is essential that the connections for each type of filament voltage supply be made according to the circuit diagram to prevent distortion and possible failure of the filament.

The plate circuit should be provided with a time-delay relay to delay the application of plate voltage until the filament has reached at least 80 per cent of the normal voltage. It must be provided also with protective devices to prevent the tube from drawing a heavy overload. The coil of an instantaneous overload relay (set for slightly higher than normal plate current) placed in the ground lead of the plate return and operating to remove the plate voltage may be used for this purpose. The total time required for the operation of the relay and breaker should be in the order of one-tenth second and not more than one-sixth second. Plate series protective resistors should also be provided to protect the tube from excessive energy dissipation during instantaneous failure of insulation, within the tube or within the transmitter. The minimum value of this resistor which will give adequate protection with minimum power loss is given on the Description and Rating Sheet. Precautions must be taken so that no high capacitance is connected directly across the tube in such a manner that a disturbance within the tube will discharge appreciable energy from the capacitor.

The grid circuit should be provided with heavy conductors, carefully connected, in order to prevent overheating of the grid terminal due to r-f currents.

to reduce the inductance of the grid circuit. If desired, to reduce coupling, one lead may be used for the neutralizing circuit and the other two for the grid-excitation circuit. When the tube is used in an oscillator circuit at the higher frequencies, it may be necessary partially to neutralize the feedback in order to prevent excess grid excitation caused by the normal grid-plate capacitance.

If two or more tubes are used in the circuit, controls should be provided so that adjustment may be made to balance properly the plate current taken by each tube.

In Class B service, grid bias of excellent regulation is usually required.

In Class C service, the bias voltage may be supplied by a grid leak, or by a combination of grid leak and generator, grid leak and rectifier, or grid leak and cathode-bias resistor suitably by-passed. The combination method is particularly suitable to reduce distortion, especially in plate-modulated operation. Since the grid-bias voltage for Class C service is not particularly critical, correct circuit adjustment may be obtained with values differing widely from those indicated for this service.

The circuits should be arranged to prevent parasitic oscillations so that the tube will not be subjected to excessive voltages and currents.

OPERATION

When a new tube is first placed in operation, it should be operated without plate voltage for fifteen minutes at rated filament voltage. After this initial preheating schedule, plate voltage can be applied. Operate for fifteen minutes at approximately one-half the usual plate voltage. Full voltage may then be applied and the tube operated under the normal load conditions for a period of one hour or more. Every three months spare tubes should be given the preheating and initial operation schedule discussed above.

The filament should be operated at constant voltage rather than constant current and must be allowed to reach at least 80 per cent normal voltage before plate voltage is applied. Intermittent power supply interruptions may be allowed provided the time off does not exceed one second. If the tube is to be used at relatively low output, the plate current will be less than normal, requiring less than normal emission of the filament. The filament, therefore, may be operated at a voltage slightly lower than rated voltage, giving longer life. The permissible reduction in filament voltage may be checked by reducing the filament voltage with the transmitter under normal operation to a value where reduction in output or increase in distortion can just be detected. The filament voltage must then be increased by an amount equivalent to the maximum percentage regulation of the filament supply voltage. Care must be taken that sufficient emission is provided.

Otherwise, instability of operation or excessive distortion may be experienced, or the rated plate dissipation of the tube may be exceeded. From the viewpoint of tube life, it is usually economically advantageous to provide good regulation of the filament voltage. For example, if the filament is operated continuously at 6 per cent above normal voltage, the evaporation life will be reduced to approximately one half.

When a three-phase or six-phase a-c filament-supply voltage is used, the phase voltages must all balance within 15 per cent during the filament starting period. During normal operation the phase voltages must never, even momentarily, exceed 10 per cent unbalance.

If the apparatus in which the tube is used is to be idle for periods not exceeding two hours, voltage should be maintained on the filament. However, if desired, provision may be made to reduce the filament voltage to approximately 80 per cent of the rated value during the stand-by. Where stand-by periods exceed two hours the filament voltage may be removed.

When direct-current filament excitation is used, the filament leads should be reversed every 500 hours of operation.

Maximum ratings and typical operating conditions for each recommended class of service are given on the Description and Rating Sheet. The amplifier classifications used are those given in the Report of the Standards Committee of the Institute of Radio Engineers.

The output values given in the tabulation on the Description and Rating Sheet are approximate tube outputs under certain typical operating conditions. These must not be used as output ratings; circuit losses must be subtracted from the tube output in calculating the useful output.

The approximate anode dissipation may be calculated from the following expression:

$$P(\text{kilowatts}) = n \frac{(T_2 - T_1)}{4}$$

in which (T_1) is the known initial temperature of the cooling water in degrees centigrade, (T_2) the temperature of the water at the water jacket outlet in degrees centigrade, and (n) the water flow in gallons per minute.

In determining the value of plate voltage for normal operation, the line voltage fluctuation, load variation, and manufacturing variations must be estimated so that the maximum rated values will not be exceeded.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced to approximately one-half the rated value to prevent damage to the tube or associated apparatus. After correct adjustment has been made with the tube operating smoothly and without excessive heating of the cooling water or the glass bulb, the plate voltage may be raised in several steps to the desired

WATER-COOLED TYPES (CONT'D)

OPERATION (CONT'D)

value. Adjustments should be made at each step for optimum operation.

In case of overload and resultant overheating of the tube, the vacuum may be impaired. When the quantity of gas is not too great, the tube may be operated to bring about an electrical cleanup of the gas. The first step in the process should be a short period of operation at a plate voltage of one-half the normal value. The plate voltage should then be increased to the normal value and the tube allowed to operate for a period of one hour or more. In severe cases it may be possible to age the tube by operating

with a series resistor in the plate supply. Short periods of operation may be conducted at each step as the resistor is reduced until stable operation at the normal plate voltage is obtained.

Before turning off the water preparatory to removing the tube, be sure that the inner electrodes are below red heat. Do not force the tube when removing it from the jacket. Release the securing device so that it will not stick, then manipulate the tube carefully to avoid putting strains on the glass. If sticking does occur, rotate the tube gently back and forth, at the same time raising it carefully.

HIGH-VACUUM RECTIFIERS INSTALLATION

Mechanical

Each tube is suspended within its shipping carton so that it will not come in contact with the sides of the carton during shipment. The tube should be stored in the carton and should be protected from moisture and extreme temperature changes. Furthermore, while the tube is being handled it should be kept in a vertical position with the cathode end down. Under no circumstances should crated tubes be piled on top of one another.

In installations where a nonrigid anode connection is used, reasonable flexibility must be provided to prevent placing a strain on the cathode base. Since the bulb becomes hot during continuous operation, it should not come in contact with any metallic body, nor be subjected to the drops or spray of any liquid.

The accumulation of dust and metallic particles on the outer surface of the glass walls will increase the leakage over this surface. As this may result in tube failure from arc-over, periodic cleaning of these surfaces should be maintained.

Cooling

Free circulation of cool air around the glass bulb should be maintained. High-temperature air from other apparatus should be prevented from circulating around the tubes.

Filament power should be supplied from a filament-lighting transformer insulated for the proper voltage. This transformer should be provided with a secondary midtap for the plate circuit return lead. The filament excitation supply must be provided with suitable resistors or other regulating devices to apply the power to the filament gradually and to adjust it accurately during operation. The filament voltage should be measured directly at the filament terminals.

The installation of all wires and connections should be made so that they do not lie on or close to the glass of the tube. An air space of approximately the length of the tube should be maintained between the bulb and any

metallic body during operation. Otherwise, corona discharge may develop and result in puncture of the glass bulb.

OPERATION

Ordinary care in handling and provision for the necessary operating conditions will minimize accidental damage to the tube.

The maximum values given in the rating of these tubes are the values beyond which it is unsafe to operate, if the maximum life and performance are desired. For example, the maximum operating plate voltage can be obtained from the Technical Information and the amount of voltage fluctuation, due to line, load, and manufacturing variation in the apparatus must be determined or estimated. An average value of plate voltage must be used which, under normal operating variations, does not exceed the maximum rated value.

The ratings given on the Technical Information prescribe two limiting operating conditions. The first is a maximum peak inverse voltage which should not exceed a certain safe value determined by the insulation between electrodes of the tube. The maximum peak inverse voltage is the highest voltage that the tube will insulate on the half cycle when no current is passing through the tube. Line surges, circuit capacitance, wave form distortion, and the maximum peak voltage of the applied alternating voltage may cause the inverse voltage to exceed the maximum peak voltage rating.

The second limiting value is the power dissipation of the plate, determined by the d-c load current and the resultant tube voltage drop. Since the over-all rectifier design, and in particular the filter capacitances, determine the amount of current available from a system, oscilloscopic checks should be made of the actual load conditions. If the rectifier is to be operated at full peak current ratings, it will be necessary to maintain exactly the rated filament voltage. If the peak current to be drawn is less than the full rated value, the allowable filament

voltage regulation increases as the value of the peak current decreases.

The following tabulation shows the reduction of the maximum peak current with reduced filament voltage:

Filament Voltage Per Cent of Rated	Maximum Peak Current Per Cent of Rated
100	100
95	65
90	40
85	25
80	10

Excessive anode temperature is an indication of abnormal voltage drop in the tube and is usually caused by low filament temperature. Filament voltage greater than the rated value, while increasing the maximum peak current available, will result in decreased tube life.

Note: The ratings and characteristics of a particular tube are given under Technical Information on the Description and Rating Sheet for that tube.

MERCURY-VAPOR RECTIFIERS—INSTALLATION AND OPERATION

INSTALLATION

Mechanical

Mercury-vapor rectifiers should be mounted in sockets or supports of good quality with connections of sufficient current-carrying capacity, and should be operated only in a vertical position, as indicated by the outline drawing. A shock-absorbing mounting must be used if the tube is to be subjected to excessive vibration or shock. Since the tube becomes hot during continuous operation, any glass parts, including the seals, should not come in contact with any metallic body; nor be subjected to the drops or spray of any liquid.

Electrical

The cathode information is given in terms of the normal heating voltage and the approximate current. The cathode should be operated preferably from an a-c source. If alternating current is not available, a d-c source may be used. With each installation it is good practice, where economically justified, to provide a voltmeter connected directly across the filament terminals of the socket.

The cathode must assume operating temperature before electron current is drawn. The delay may be accomplished either by manual or automatic control of the anode circuit. The automatic method is recommended where economically justified, because of the greater protection. The time required for the cathode to come up to normal operating temperature under conditions of good filament circuit regulation is included under Technical Information. In the case of mercury-filled tubes, it is also necessary to bring the condensed-mercury temperature to the minimum operating value. Where the ambient temperature is low and/or where the cathode is quick-heating, this may require a longer time than to bring the cathode to proper temperature.

When tubes with the midtapped filamentary type of cathode are used, the return leads from the anode circuit should be connected to the midtap. If the filament is not midtapped, these leads should be connected to the midtap of the filament transformer winding in the case of

alternating current, or to the negative filament terminal in the case of a d-c supply. When an a-c supply is used, it is desirable both with the midtapped filamentary type of cathode and with the type where the filament is not midtapped, to use a filament winding with the filament voltage approximately 90 degrees out of phase with the anode voltage. However, the midtap of the filament transformer must not be used with tubes employing the indirectly heated type of cathode. In tubes of this type, the cathode is connected to one side of the filament, and only corresponding filament prongs should be connected when operating the filaments of two or more tubes in parallel.

An appreciable glow in the tube, when plate voltage is not applied, is an indication that the tube is exposed to radio frequency. Such a condition should be corrected; otherwise the tube life and performance will be adversely affected.

Thermal

When a mercury-vapor tube is first placed in operation, it is necessary to distribute the mercury properly before anode voltage is applied. This is usually accomplished by applying filament voltage for a period of time sufficient to distill the mercury into the cooling chamber of the tube. The location of the cooling chamber is indicated on the outline drawing by the words "controlling mercury temperature."

This time is generally less than one hour. This procedure need not be repeated unless, during subsequent handling or treatment the mercury is spattered or distilled on the elements or upper portion of the tube.

The design of equipment in which a mercury-vapor tube is used, should be such as to ensure the tube's operating within the condensed-mercury temperature limits over the range of ambient temperatures to be encountered.

When mercury-vapor tubes are subjected to low ambient temperatures or when it is desired to reduce the mercury-heating time (the time required to raise the mercury temperature to operating range), some form of heat-conserving enclosure should be used. This may be provided

MERCURY-VAPOR RECTIFIERS

INSTALLATION (CONT'D)

with thermostatically controlled shutters and/or heaters to bring the condensed-mercury temperature up within the operating range. When heaters are used, they should be located in such a position that the normal condensed-mercury region always remains the coolest portion of the tube enclosure.

When high ambient temperatures are encountered, it may be possible to utilize "chimneylike" enclosures to increase the natural convection cooling. In some cases the use of forced air may be necessary.

OPERATION

Careful handling and conservative operation will be amply repaid by longer and more uniform tube life. Three of the fundamental limits on the operation of mercury-vapor tubes are the maximum peak inverse anode voltage, maximum instantaneous anode current, and the maximum average anode current.

Cathode Circuit

The cathode voltage, as indicated by the voltmeter, should not deviate from the rated value by more than five per cent. Filament voltage should be set so that voltage fluctuations give an average value equal to the rated filament voltage. Too low filament voltage may result in very short life or perhaps immediate failure due to loss of emission. Too high voltage will shorten the life of the cathode somewhat.

During stand-by periods the filament should be operated at normal voltage.

Anode Circuit

The peak inverse voltage applied to the anode should never exceed the rated value. In the usual single-phase circuits, the peak inverse voltage, for sine-wave conditions may be taken as the total anode-transformer secondary voltage (rms value) multiplied by 1.4. The relations between the peak inverse voltage, the direct voltage, and the rms value of alternating voltage depend largely upon the individual characteristics of the rectifier circuit and the power supply. Line surges, keying surges or any other transient or wave-form distortion may raise the actual peak voltage to a value which is higher than that calculated from the sine-wave voltages in the transformer. It should, therefore, be emphasized that the maximum rating of the tube refers to the actual inverse voltage and not to the calculated values. A cathode-ray oscilloscope or a spark gap connected across the tube is useful in determining the actual peak inverse voltage.

The instantaneous anode current experienced is affected largely by the characteristics of the output circuit, including a filter if one is used. In the case of a circuit giving full-wave rectification, if the output circuit is highly inductive with respect to the tube, the instantaneous current may approach the d-c reading in the load circuit. If the output circuit is highly capacitive with respect to the tube, the instantaneous current in the tube may be many times the load current. Analysis of the individual circuit is necessary.

The average anode current must not exceed the rated value. With a steady load this may be read directly on a d-c meter. In the case of fluctuating loads, however, the reading should be averaged over a period not exceeding the time shown under Technical Information.

The maximum surge current is the maximum instantaneous current that can pass through the tube under the most adverse conditions. This rating is intended to form a basis for set design, as it not only limits the currents which might flow during abnormal conditions, but also assures more reliable tube performance than would be obtained with circuits having too low a value of impedance. It does not mean that the tubes can be subjected to short circuit without the probability of a corresponding reduction in life and the possibility of failure. The duration of the surge current shall not be greater than the time shown on the Technical Information.

The voltage drop from anode to cathode is so low that it has little effect on the complete circuit except when the anode voltage used is low. This drop varies with the cathode voltage, with individual tubes, with life, and (in the case of mercury tubes) with the ambient temperature. The range given covers the maximum variations caused by all these factors as long as the tube is operated under the allowable conditions. Rapid changes are rarely encountered.

In installations where uninterrupted service is desired, the tube voltage drop should be checked at regular intervals. Since the tube drop is one criterion of tube condition, failure of tubes may be determined and even anticipated. The end of life will usually be preceded by an acceleration in the rate of increase at the test intervals. Tubes should be withdrawn from use at the beginning of this stage for maximum reliability of the installation.

NOTICE: GAS- OR VAPOR-FILLED TUBES, BECAUSE OF THEIR CONSTANT DROP PROPERTIES, REQUIRE SUFFICIENT PROTECTIVE RESISTANCE IN THE ANODE CIRCUIT TO LIMIT THE CURRENT TO THE RATED VALUE.

TUBE DEPARTMENT

GENERAL  ELECTRIC

Schenectady 5, N. Y.

GENERAL  ELECTRIC

LIGHTHOUSE TUBES



DESCRIPTION

The disk-seal triodes 2C39, 2C43, and 3C22 are used in transmitting applications as power amplifiers, c-w and pulsed oscillation generators for frequencies up to 3000 megacycles per second or higher. Their unique performance characteristics in the microwave range result from the following mechanical design features:

1. Lead inductances are reduced to a negligible value by use of the disk seals.
2. The parallel-plane structure permits the use of relatively small electrode areas; this makes possible low interelectrode capacitances, even with the close spacing of electrodes which is necessary at the frequencies at which the tubes operate.
3. Although the relatively small anode area makes radiation cooling from the anode

surface impracticable, the anode lead has the same cross-sectional diameter as the anode surface, and heat conduction through the lead to the external circuit makes cooling relatively simple.

4. The coaxial structure makes possible practically complete enclosure of the radio-frequency fields in the types of circuits described later. This factor is extremely important in the microwave range where radiation from practical open-wire circuits becomes excessive.
5. Silver-plated parts reduce radio-frequency resistance to a minimum.

Another important application consideration features external cavities which allow continuous tuning and replacement of tubes without changing the cavity.

AMPLIFIER APPLICATIONS*

Power Amplifier

The useful frequency range of the disk-seal tube may be divided into three parts: a low-frequency range, a higher-frequency range, and a transition range. The frequency dividing lines are not actually fixed but depend upon the operating voltages, the external circuit used, and, of course, the tube type. For general purposes the lower range may be taken as those frequencies below 500 megacycles per second, the upper range those above 1000 megacycles per second, and the transition range those frequencies between 500 and 1000 megacycles per second. In the lower range, parallel-wire-line-type circuits are most commonly used, transit-time effects in the tube are negligible or small, and end effects due to the tube are small though not completely negligible. Efficiencies of operation in the low range are good and performance may be calculated with satisfactory accuracy from the d-c characteristics by using standard techniques. Ordinary precautions in the circuit assembly are sufficient to give good circuit efficiency, since shunting impedances due to ordinary losses are appreciably higher than the low load impedance required by G-E lighthouse tubes. Plate modulation may be used to give audio modulation without appreciable frequency-modulation and with reasonably low harmonic distortion.

In the higher-frequency range, the output, efficiency, and power gain fall off, and eventually reach zero at some frequency which depends upon the tube type but is appreciably above 3000 megacycles per second for the 2C39 and 2C43 tubes,

but nearer 2000 megacycles per second for the 3C22. Self-enclosed coaxial circuits are used almost exclusively and much greater care must be used in guarding against radiation losses, poor contacts, leaky by-pass capacitors, and corrosion of circuits, since the tubes require much higher load impedances in this frequency range. Plate modulation produces phase as well as amplitude modulation because of transit-time effects in the tube.

The intermediate range is defined as the range of transition which lies between the two frequency extremes, and so has characteristics somewhere between the two.

Grounded-grid amplifier circuits are used almost exclusively with these tubes in all the ranges from 200 megacycles per second up. That is, one resonator is connected between plate and grid, and a second resonator between grid and cathode. This is done at the lower frequencies to decrease regeneration due to the grid-plate capacitance. The plate-cathode capacitance, the feedback element in a grid-return circuit, is smaller than the plate-grid capacitance by a factor of about 100, resulting in negligible regeneration in the lower-frequency range. This eliminates the need for undesirable neutralizing circuits. In the highest ranges of usefulness, the feedback susceptance arising from the finite plate-cathode capacitance is not completely negligible, and may give regeneration difficulties. It is possible, but not easy, to neutralize this feedback with the proper amount of external feedback. With self-enclosed coaxial circuits used at the highest frequencies, the grounded-grid type of circuit is also the only choice from mechanical considerations, for it is physically impossible to connect a self-enclosed, cathode-return-type circuit to the tube.

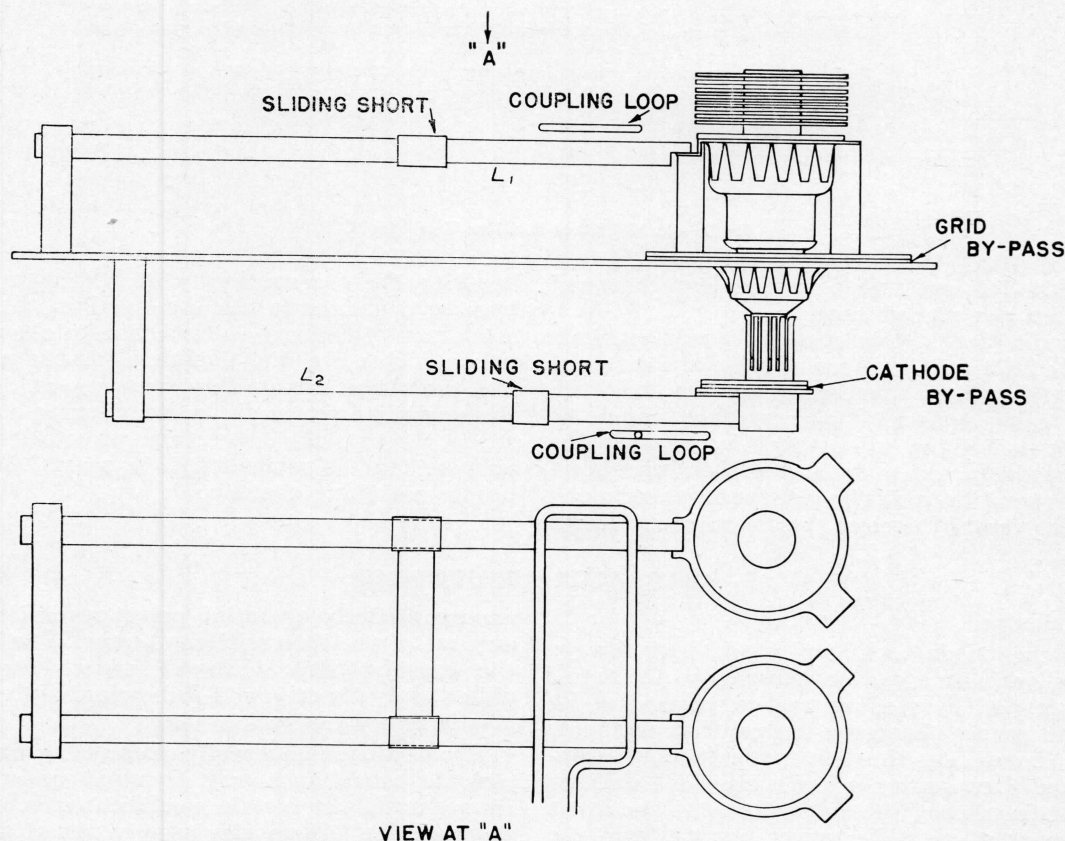
* Circuits shown in ETX-110 are examples of possible tube applications and the description and illustration of them does not convey to the purchaser of tubes any license under patent rights of General Electric Company.

AMPLIFIER APPLICATIONS (CONT'D)

Low-Frequency Amplifier

The circuit in Fig. 1 using 2C39 tubes is an example of the parallel-wire-line circuits used with the disk-seal tubes in the few hundred megacycles per second range.

a grid-leak resistance, a cathode resistance, or a combination of the two. The filament leads are brought out through the hollow conductors of the cathode-to-cathode line. Power may be coupled in and out by means of loops placed with their



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Fig. 1—Push-Pull Power-Amplifier Circuit for 2C39 Using Parallel-Wire Lines

The circuit is a grounded-grid connection and the two tubes are set with axes parallel, their grid rings making good contact with the conducting grid plane. One parallel-wire line is connected between the two anodes and runs parallel to the grid plane on the upper side, a second similar line is connected between the two cathodes on the under side. Both lines have sliding, shorting bars for tuning, and conducting plates should be connected to these bars to close off the dead region of the line from the active region. B-supply voltage is applied between the plate-to-plate line and the cathode-to-cathode line; bias voltage is applied between the cathode-to-cathode line and ground. This bias usually may be obtained by means of

planes parallel to the plane of the cathode-to-cathode and plate-to-plate lines respectively. Suitable matching arrangements should be provided on the lines to match to the driving source and to the load.

The entire circuit described above may be enclosed in a shielded box to prevent the occurrence of stray losses and feedback effects. If regeneration difficulties still persist, the contact to the grid ring should be investigated, for slight leaks through this contact invariably cause trouble. A lead sleeve placed around the grid ring before the grid ring makes contact with the circuit will often eliminate this difficulty.

AMPLIFIER APPLICATIONS (CONT'D)

Higher-Frequency Amplifier

The power-amplifier circuit in Fig. 2, also using Type 2C39, is an example of the coaxial circuits

than in the design of lower frequency circuits. As shown, it consists of a larger coaxial line connected between plate and grid, with a by-pass capacitor

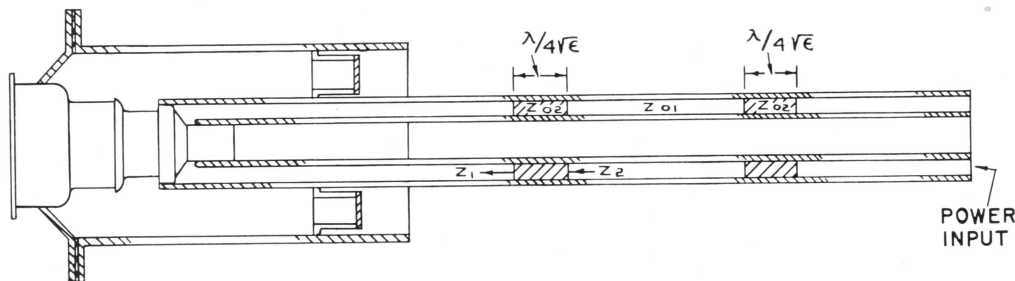


Fig. 2—Coaxial Power-Amplifier Circuit for 2C39

used with disk-seal tubes in the few thousand megacycles per second range.

The input line in this example is not so much a tuned circuit as it is a transmission line matched to the grid-cathode impedance by the dielectric slug matching system. This is possible because of the low value of the grid-cathode impedance. The output resonator must develop a high impedance for good operation in this frequency range, and much more care must, therefore, be taken in its design

breaking the d-c continuity at the plate end. A by-pass capacitor is also provided in the center conductor of the grid-cathode line to allow application of bias. A sliding plunger closes the resonator and tunes the circuit. Power is coupled out from the grid-plate resonator by introducing a loop or probe through the open tube provided for this purpose, and is connected to a coaxial line with proper matching controls.

OSCILLATOR APPLICATIONS

C-W Oscillator

Since the triode oscillator circuit may always be considered as a power amplifier with its r-f input supplied by feeding back a portion of its output in proper phase, the design of an oscillator consists in making the best possible power amplifier and then adding a feedback which delivers the right fraction of the output back to the input with proper phase. The power output from the oscillator would be expected to be less than that

from a similarly operating power amplifier by the amount of the input driving power. Nearly all of the considerations discussed under Power Amplifier apply directly, and it remains only to design a satisfactory feedback system.

The feedback inherently present in the plate-cathode capacitance was discussed under Power Amplifier. Under certain conditions it is sufficient to cause oscillations, but usually not of sufficient strength to make a good power oscillator. Loops,

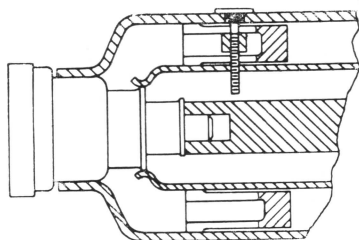


Fig. 3A—Movable Probe Feedback, Folded-Back Cavity

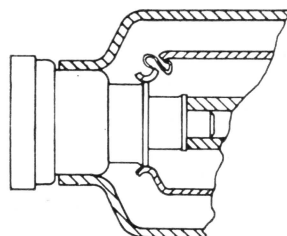


Fig. 3C—Loop Feedback, Folded-Back Cavity

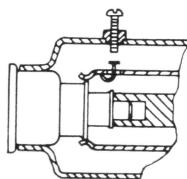


Fig. 3B—Loop-Probe Feedback, Folded-Back Cavity
K-5109739

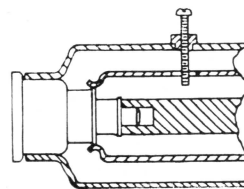


Fig. 3D—Fixed-Probe Feedback, Folded-Back Cavity

OSCILLATOR APPLICATIONS (CONT'D)

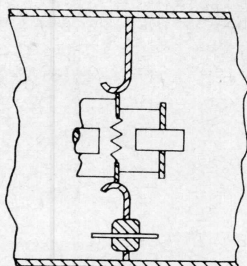


Fig. 3E—Probe Feedback, End-to-End Cavity

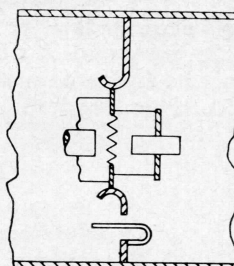


Fig. 3G—Loop-Probe Feedback, End-to-End Cavity

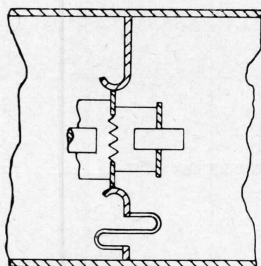


Fig. 3F—Loop Feedback, End-to-End Cavity

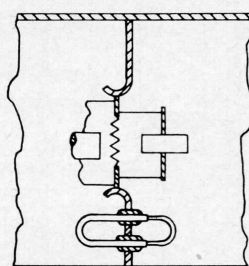
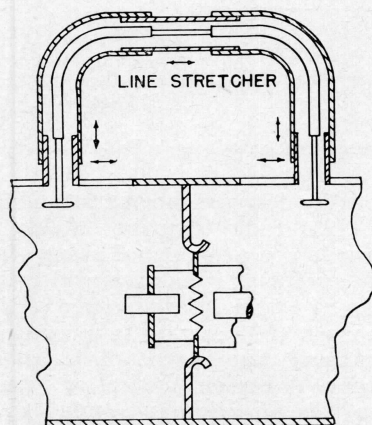
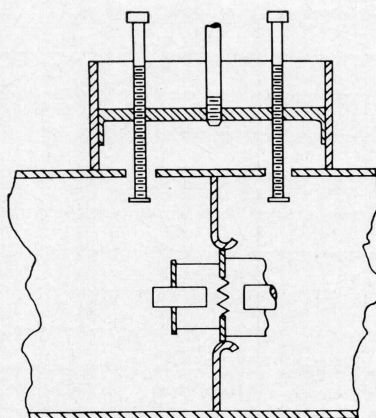


Fig. 3H—Adjustable Loop Feedback, End-to-End Cavity

K-5109740

3-28-45



K-5109741

Fig. 3J and 3K—Adjustable Probe Feedback with Phasing Network, End-to-End Cavity

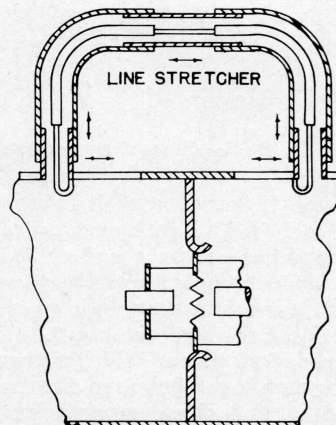


Fig. 3L—Adjustable Loop Feedback with Phasing Network, End-to-End Cavity

3-28-45

OSCILLATOR APPLICATIONS (CONT'D)

probes, or holes between the input and output cavities are favorite means of obtaining additional feedback. Several methods of applying loop and probe feedbacks in their simplest forms are shown

frequency for this circuit. In the re-entrant circuit the radio-frequency fields from the grid-plate space are coupled directly back to the grid-cathode space. The figures shown below and the explanation fol-

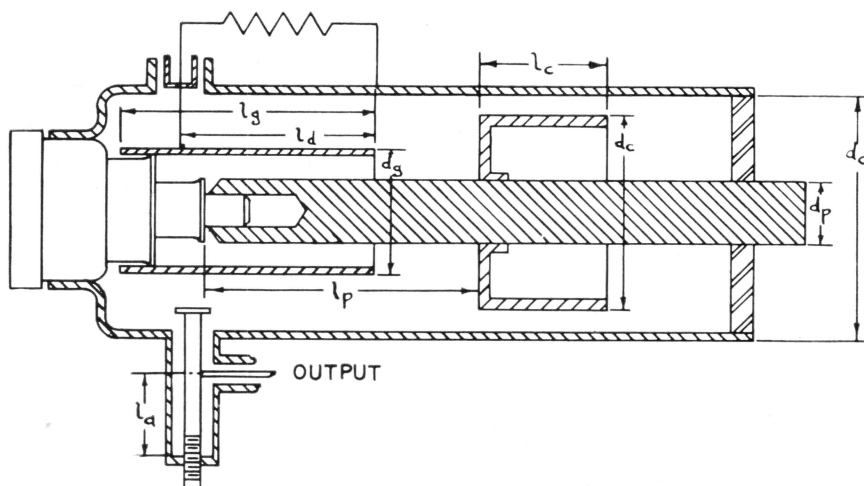
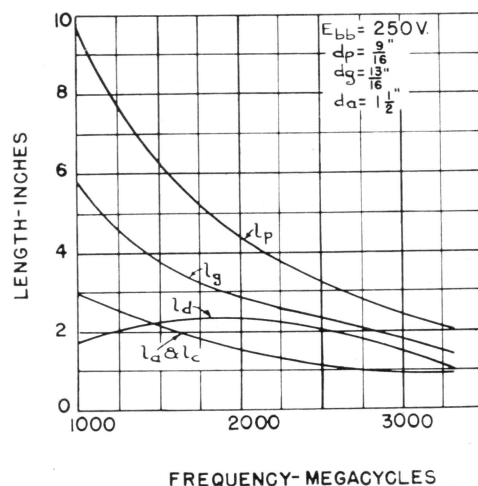


Fig. 4—Re-entrant Oscillator Circuit



K-5109727

12-15-44

Fig. 5—Curves of Approximate Dimensions for Circuit Shown in Fig. 4

in Fig. 3A to 3H on page 5, together with cavities suitable for the 2C40 and 2C43 lighthouse tubes.

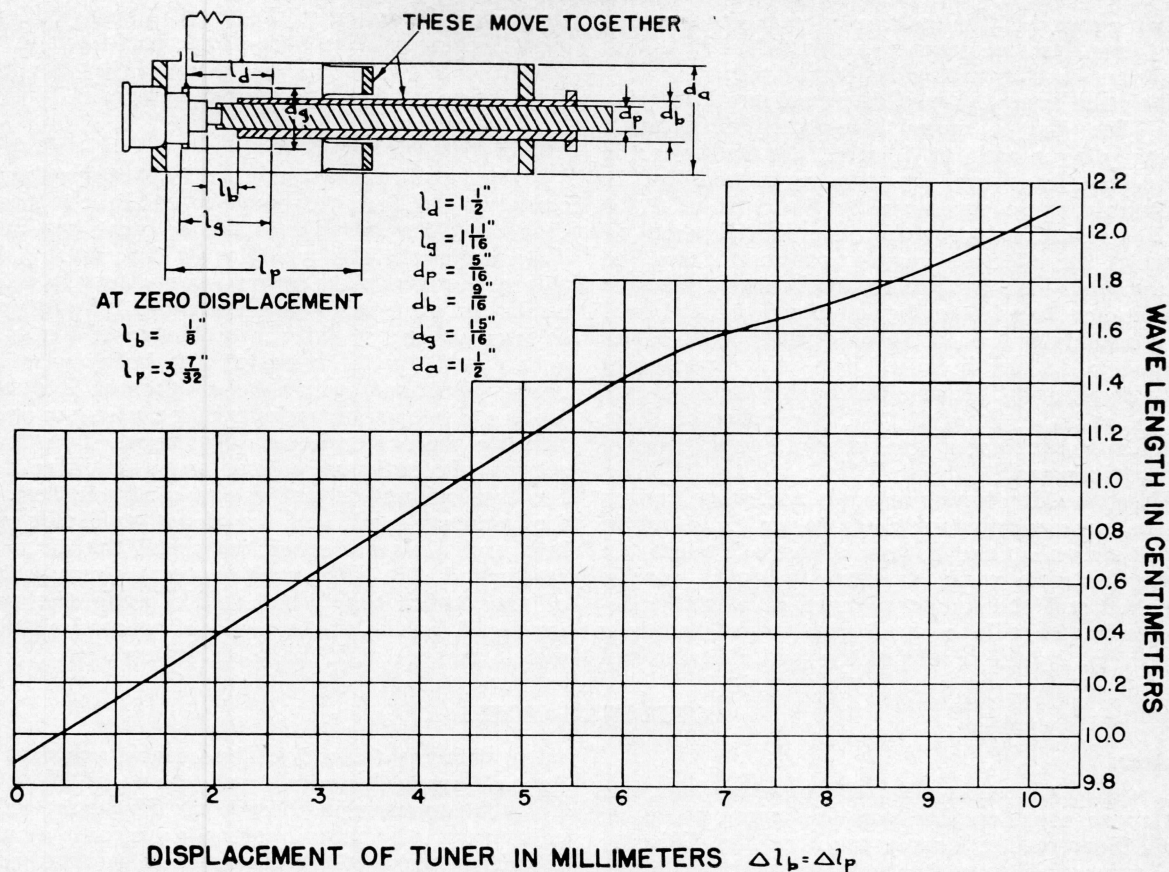
The limitations on the use of the simplest loop and probe feedbacks arise mainly because these feedbacks do not have parameters enough to adjust both the phase of feedback and the magnitude of feedback to optimum. Fig. 3J and 3K illustrate the addition of phasing networks between the two loops or probes to control the phase separately.

A modified oscillator circuit particularly useful above 2000 megacycles is shown in Fig. 4 above. This circuit is commonly called a re-entrant oscillator. Fig. 5 shows a curve of essential dimensions versus

lowing describe the operation of this type of circuit.

The radio-frequency fields between grid and anode are propagated along the grid-plate line to the point at which the grid cylinder is terminated. At this point, the presence of the choke or plunger causes this energy to propagate along the grid-cathode line in the direction of the base of the tube. A certain amount of the power propagated in this direction is coupled to the output by the output probe, and enough additional power to supply the tube loss is fed back into the grid-cathode circuit, thus sustaining oscillation. The length of the grid cylinder, l_g , is the most im-

OSCILLATOR APPLICATIONS (CONT'D)



K-5109742

Fig. 6—Method for Tuning Re-entrant Oscillator

12-22-44

portant factor in determining frequency. The position of the choke, l_p , with respect to the anode of the tube has some small effect upon frequency, but for the most part, the choke is primarily important in its ability to change the phase of the feedback to the cathode. In this respect its position affects quite materially the efficiency of the oscillator. The length of the choke, l_c , is made one-quarter wave length at the center of the frequency band to be tuned. This provides

essentially a radio-frequency short circuit on the tube side of this choke, yet provides for isolation of d-c voltages.

Tuning of the re-entrant oscillator can be accomplished in a number of ways; two recommended methods are illustrated here. Fig. 6 above shows a method of tuning which utilizes a two-piece concentric rod which makes connection to the plate of the tube. The inner rod is held in a fixed position and the outer cylinder slides over it. The

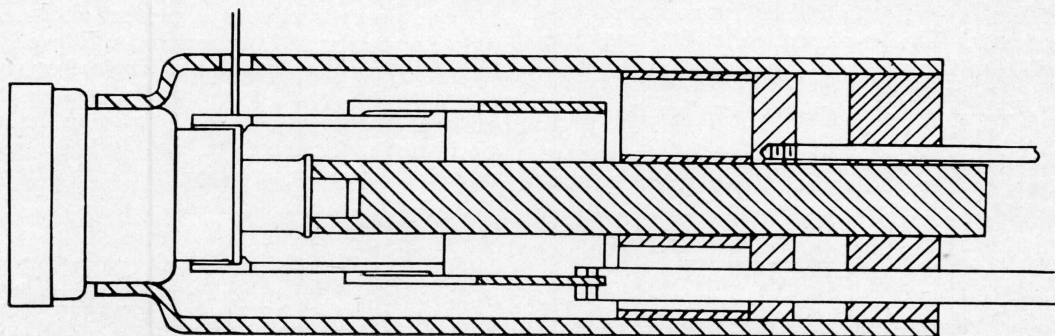


Fig. 7—Method for Tuning Re-entrant Oscillator Circuit over a Wider Range than Is Possible with Circuit in Fig. 6

K-5109743

12-20-44

OSCILLATOR APPLICATIONS (CONT'D)

tuning range of this particular oscillator versus the tuner displacement is shown. A simple explanation for this tuning action follows:

With the tuner at zero displacement, the grid-plate line has a surge impedance determined primarily by a ratio of d_g to d_p . As the tuner is withdrawn, the surge impedance of the line is determined more and more by the ratio of d_g to d_p . The result is that as the tuner is slowly moved outward, the effective surge impedance of the line is increased. This in turn results in more effective capacitance foreshortening of the line, and will therefore make the oscillator operate at a lower frequency. It can be seen from this explanation that the primary factors affecting the tuning range are the ratios d_g/d_p and d_b/d_p . As either of these ratios is made larger, the possible tuning range will be increased.

Where a wider tuning range is necessary, tuning can be accomplished in the manner indicated in Fig. 7 shown at the bottom of page 7. Here the grid cylinder is made so that its length can be extended and the anode plunger is moved independently. In this case, frequency is primarily determined by the length of the grid cylinder and

frequency decreases as the length of the grid cylinder increases. The phase of the feed-back in the oscillator is controlled independently by the position of the plunger on the anode line.

Pulsed Oscillator

Pulsed oscillators using the 2C43 tube are not essentially different from c-w oscillators except that the plate by-pass capacitor must not break down under the high voltages of plate pulsing. For this reason the plate by-pass capacitors in pulsed oscillators are generally of the choke-by-pass type, as used in the re-entrant oscillator of Fig. 4. A given oscillator, if operated for both pulse and c-w applications, will have a different frequency under pulse conditions from that under c-w operation for the same circuit adjustment. The circuit settings for optimum output are also different for the two operations and a c-w oscillator designed for optimum conditions occasionally will not oscillate under pulsed conditions until the circuit is readjusted. All of these phenomena occur because of the transit-time phase shift inside the tube, expressed as the phase angle of transadmittance, which changes with the plate voltage.

OPERATING NOTES

Contacts

Losses have greater effect as frequency increases and more consideration must be given to avoid them. Poor contacts cause much of the difficulty in circuits which operate inefficiently at the higher frequencies. For this reason, all contacts should be carefully soldered if possible. When an unsoldered contact cannot be avoided, the contact should be kept clean and subjected to pressure. Sliding contacts, as on tuning plungers, should be designed so that the finger contacts are stiff enough to exert a firm pressure against the member on which they slide without binding or gouging.

By-Pass Capacitors

Suitable by-pass capacitors in c-w oscillators may be made by using a sheet of mica between two plates for a flat by-pass capacitor and between two cylinders or conical surfaces for a coaxial by-pass capacitor. The capacitance value may be estimated from the approximate formula.

$$C = \frac{0.0885 E' A}{d}, \text{ in micromicrofarads}$$

where A is the area of effective surface in square centimeters, d , the thickness of the mica in centimeters, and E' , the specific dielectric constant of

mica, which is about 5.4. The capacitance required depends upon frequency and the location of the by-pass capacitor in the circuit. However, values of at least 100 micromicrofarads are recommended in critical parts of the circuit even at 3000 megacycles. Space limitations sometimes make it difficult to provide this capacitance since the mica thickness must be maintained large enough to withstand the voltage; 100 volts per millimeter of mica is conservative.

The choke-type by-pass capacitors used in the oscillator of Fig. 4 and shown again in Fig. 8a are in reality transmission line filters. The impedance, Z_3 , is infinite if the length l is one-quarter wave length. Impedance, Z_4 , is usually low, so that the terminating impedance, Z_2 , which is equal to Z_3 , and Z_4 in series, is infinite. The input impedance Z_1 is then zero, omitting losses, and the plunger acts as a perfect short circuit to radio-frequency and is open to d-c. The adjustment is exactly correct only for a single frequency, but is reasonably good over bandwidths of 10 to 20 per cent. More choke sections may be added if one is not sufficient (Fig. 8b) and, for wide-band tuning, these may be adjusted to slightly different frequencies.



Fig. 8—Circuit Illustrating Filter Effect of Choke-Type By-Pass Capacitors

OPERATING NOTES (CONT'D)

Modulation

Conventional plate modulation of disk-seal power amplifier tubes may be used to obtain amplitude modulation approaching 100 per cent with reasonable distortion at the lower-frequency range where transit times are negligible. When the transit time and consequent phase angle of transadmittance is important, plate voltage changes cause changes in phase as well as amplitude, thus producing phase modulation as well as amplitude modulation.

For similar reasons, plate voltage changes in an oscillator at transit-time frequencies, produce frequency modulation as well as amplitude modulation.

Back Heating of Cathode

All space-charge control tubes, when operated with relatively high-power signals (class B or C)

in the transit-time range, exhibit effects of cathode bombardment caused by electrons returned to the cathode by the reversal of electric field before the electrons reach the grid-plate region. This effect is noticeable in the disk-seal triodes near the upper limits of useful frequency, and may appreciably decrease cathode life if heater power is not reduced. The energy in the returned electrons comes from the radio-frequency driving source, so that the phenomenon is accompanied by an increase in effective input conductance.

The returned electrons are also responsible for some of the decrease in output, since they represent a decrease in the useful current passing into the grid-plate region. Since the phenomenon becomes more marked with increased degree of Class-C operation, extreme Class-C conditions should be avoided at frequencies where this is an important factor in tube performance.

ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
Schenectady 5, N. Y.

RECOMMENDED TYPES AND SELECTION CHART

Transmitting Tubes

LIGHTHOUSE AND PLANAR TYPES

Class A Radio-Frequency Amplifiers

Frequency for Maximum Ratings, Megacycles	Typical Performance	Tube Type
3370	8.5 db Noise, 15 db Gain at 700 MC	GL-2C40 GL-2C40-A

Class A₁ Amplifiers

3000	13.2 db Noise, Greater than 10 db Gain 8.2 db Noise at 1200 MC, Greater than 15 db Gain 4 to 5 db Noise at 400 MC, Greater than 17 db Gain	GL-6299 (Ceramic)
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Class C Radio-Frequency Amplifiers and CW Oscillators

1500	Frequency Multiplier Service—Tripling to 300 MC Two Tubes in Push-pull—4.4 Watts Output	GL-2C43
2500	17 Watts Output as a Power Oscillator 40 Watts Output at 500 MC 20 Watts Output at 1850 MC with 2.5 Watts Drive	GL-2C39-B (Ceramic) GL-6897 (Ceramic)
	2.0 Watts Output	GL-6442 (Ceramic)
3370	0.075 Watts Output	GL-2C40 GL-2C40-A
4000	300 Milliwatts as a Local Oscillator As a Doubler to 1000 MC, 2 Watts Output with 300 Milliwatts Drive	GL-6771 (Ceramic)

Plate-Pulsed Power Oscillators

3370	300 Watts Peak Output at 3000 MC	GL-2C40-A
	1.75 Kilowatts Peak Output	GL-2C43
4000-5000	2.0 Kilowatts Peak Output at 3500 MC Greater than 500 Watts at 5000 MC	GL-6442 (Ceramic)

TRIODES
Audio-Frequency Amplifiers and Modulators—Class A

Frequency for Maximum Ratings, Megacycles	Cooling	Plate Power Output, Kilo- watts	Maximum Ratings				Typical Operating Conditions				Tube Type
			DC Plate Voltage, Volts	DC Plate Current, Amperes	Plate Input, Kilo- watts	Plate Dissipa- tion, Kilowatts	DC Plate Voltage, Volts	DC Plate Current, Amperes	DC Grid Voltage, Volts	Driving Power, Watts	
3.0*	Natural Ventilation	0.16	2500	...	...	0.6	2500	0.240	—92	...	GL-851

Audio-Frequency Amplifiers—Class B

Frequency for Maximum Ratings, Megacycles	Cooling	Plate Power Output, Kilo- watts (2 Tubes)	Maximum Ratings				Typical Operating Conditions (Ratings are for 2 Tubes)				Tube Type
			DC Plate Voltage, Volts	DC Plate Current, Amperes	Plate Input, Kilo- watts	Plate Dissipa- tion, Kilo- watts	DC Plate Voltage, Volts	DC Plate Current, Amperes	DC Grid Voltage, Volts	Driving Power, Watts	
1.6	Water and Forced-air	90	15,000	7.5	100	50	12,000	13	0	450	GL-862-A
									—100	6000	GL-898-A§
3.0*	Natural Ventilation	2.4	3000†	1.0	2.250	0.750	3000	1.2	—135	6.0	GL-851
25*	Water and Forced-air	46	10,500	5.0	40	15	10,000	1.0	—450	540	GL-880
		55	12,500	5.0	45	22.5	12,500	6.4	—600	430	GL-7085/356
40*	Forced-air	15	8500	2.0	12	5.0	7500	3.2	—300	150	GL-889R-A
50*	Water and Forced-air	15	8500	2.0	12	5.0	7500	0.4	—300	150	GL-889-A

Radio-Frequency Power Amplifiers—Class B Telephony

Frequency for Maximum Ratings, Megacycles	Cooling	Plate Power Output, Kilo- watts	Maximum Ratings				Typical Operating Conditions				Tube Type
			DC Plate Voltage, Volts	DC Plate Current, Amperes	Plate Input, Kilo- watts	Plate Dissipa- tion, Kilowatts	DC Plate Voltage, Volts	DC Plate Current, Amperes	DC Grid Voltage, Volts	Driving Power, Watts	
1.6	Water and Forced-air	25	20,000	5.0	100	75	18,000	4.2	—200	1100	GL-862-A
									—250	1100	GL-898-A§
3.0*	Natural Ventilation	0.325	2500	0.750	1.1	0.750	2500	0.39	—110	20	GL-851
25*	Water and Forced-air	9	10,500	4.0	32	20	10,000	2.75	—460	900	GL-880
		12	12,500	4.0	33	22.5	12,500	2.4	—625	1070	GL-7085/356
40*	Forced-air	2.0	8500	1.0	7.5	5.0	7500	0.9	—300	80	GL-889R-A
50*	Water and Forced-air	2.0	8500	1.0	7.5	5.0	7500	0.9	—300	80	GL-889-A
220	Forced-air	0.480	4000	0.83	1.8	1.2	3000	0.470	—25	187	GL-5513†

TRIODES (Cont'd)

Radio-Frequency Amplifiers—Class B Television Service†

Frequency for Maximum Ratings, Megacycles	Cooling	Plate Power Output, Kilo-watts	Maximum Ratings				Typical Operating Conditions				Tube Type
			DC Plate Voltage, Volts	DC Plate Current, Amperes	Plate Input, Kilo-watts	Plate Dissipation, Kilo-watts	DC Plate Voltage, Volts	DC Plate Current, Amperes	DC Grid Voltage, Volts	Driving Power, Watts	
220	Forced-air	1.125	3000	1.2	3.3	1.2	2000	0.967	—20	223	GL-5513
	Water and Forced-air	4.9	6000	2.25	13.5	7.0	5000	2.1	—300	1060	GL-6039

Plate-Modulated Radio-Frequency Amplifiers—Class C Telephony

Frequency for Maximum Ratings, Megacycles	Cooling	Plate Power Output, Kilo-watts	Maximum Ratings				Typical Operating Conditions				Tube Type
			DC Plate Voltage, Volts	DC Plate Current, Amperes	Plate Input, Kilo-watts	Plate Dissipation, Kilo-watts	DC Plate Voltage, Volts	DC Plate Current, Amperes	DC Grid Voltage, Volts	Driving Power, Watts	
1.6	Water and Forced-air	45	12,000	5.0	60	50	12,000	5.0	—800	2000	GL-862-A GL-898-A§
3.0*	Natural Ventilation	1.25	2000	1.0	1.8	0.5	2000	0.85	—300	65	GL-851
25*	Water and Forced-air	27	10,500	3.6	36	12	10,000	3.6	—1200	1100	GL-880
		29	10,000	4.0	40	15	10,000	3.8	—840	1010	GL-7085/356
40*	Forced-air	4	6000	1.0	6.0	3.0	6000	1.0	—900	140	GL-889R-A
50*	Water and Forced-air	4	6000	1.0	6.0	3.0	6000	1.0	—900	140	GL-889-A
220	Forced-air	1.25	3200	0.83	2.1	0.8	2800	0.60	—150	202	GL-5513†

Radio-Frequency Amplifiers—Class C Telegraphy

Frequency for Maximum Ratings, Megacycles	Cooling	Plate Power Output, Kilo-watts	Maximum Ratings				Typical Operating Conditions				Tube Type
			DC Plate Voltage, Volts	DC Plate Current, Amperes	Plate Input, Kilo-watts	Plate Dissipation, Kilo-watts	DC Plate Voltage, Volts	DC Plate Current, Amperes	DC Grid Voltage, Volts	Driving Power, Watts	
1.6	Water and Forced-air	100	20,000	10.0	200	100	18,000	8.33	—1000	2400	GL-862-A GL-898-A§
3.0*	Natural Ventilation	1.7	2500	1.0	2.5	0.75	2500	0.9	—250	45	GL-851
25*	Water and Forced-air	40	15,000	4.5	67.5	20	10,000	6.0	—1000	1500	GL-880
		42	12,500	6.0	60	22.5	12,500	4.7	—1400	850	GL-7085/356
40*	Forced-air	10	8500	2.0	16	5.0	7500	2.0	—800	400	GL-889R-A
50*	Water and Forced-air	10	8500	2.0	16	5.0	7500	2.0	—800	400	GL-889-A
110	Forced-air	6.5	7000	1.8	12	4.0	6600	1.3	—520	180	GL-5518
220	Forced-air	2.690	4000	1.0	3.6	1.2	3750	0.94	—150	377	GL-5513†
	Water and Forced-air	12.8	7500	2.25	16	7.0	7000	2.08	—900	3400	GL-6039†

* Tubes may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is increased.

† Grounded-grid operation.

‡ Synchronizing-level conditions per tube.

§ Three-section filament.

TETRODES**Radio-Frequency Amplifiers—Class B Television Service*†**

Frequency for Maximum Ratings, Megacycles	Cooling	Plate Power Output, Kilo-watts	Maximum Ratings				Typical Operating Conditions				Tube Type
			DC Plate Voltage, Volts	DC Plate Current, Amperes	Plate Input, Kilo-watts	Plate Dissipation, Kilowatts	DC Plate Voltage, Volts	DC Plate Current, Amperes	DC Grid Voltage, Volts	Driving Power, Watts	
220	Water and Forced-air	25	7000	8.0	50	25	6800	7.5	—20	2300	GL-6251
900	Forced-air	0.260	1600	0.400	0.600	0.300	1500	400	—25	25	GL-6283
		1.0	4000	0.7	2.5	1.5	3500	0.520	—40	100	GL-6942
	Water and Forced-air	1.0	4000	0.7	2.5	2.0	3500	0.520	—40	100	GL-6019

Radio-Frequency Amplifiers—Class C Telegraphy

Frequency for Maximum Ratings, Megacycles	Cooling	Plate Power Output, Kilo-watts	Maximum Ratings				Typical Operating Conditions				Tube Type
			DC Plate Voltage, Volts	DC Plate Current, Amperes	Plate Input, Kilo-watts	Plate Dissipation, Kilowatts	DC Plate Voltage, Volts	DC Plate Current, Amperes	DC Grid Voltage, Volts	Driving Power, Watts	
110	Forced-air	1.575	4000	1.0	3.0	1.2	3750	0.67	—102	60	GL-7D21
900	Forced-air	0.154	1600	0.300	0.450	0.300	1500	0.290	—40	12	GL-6283†
		1.2	4000	0.7	2.5	1.5	3800	0.500	—120	150	GL-6942†
	Water and Forced-air	1.2	4000	0.7	2.8	2.0	4000	0.550	—120	150	GL-6019
		1.5	6000	1.0	5.0	3.0	4500	0.6	—120	90	GL-6182†

Plate-Modulated Radio-Frequency Amplifiers—Class C Telephony†

Frequency for Maximum Ratings, Megacycles	Cooling	Plate Power Output, Kilo-watts	Maximum Ratings				Typical Operating Conditions				Tube Type
			DC Plate Voltage, Volts	DC Plate Current, Amperes	Plate Input, Kilo-watts	Plate Dissipation, Kilo-watts	DC Plate Voltage, Volts	DC Plate Current, Amperes	DC Grid Voltage, Volts	Driving Power, Watts	
900	Forced-air	0.565	3200	0.35	1.12	1.2	3000	0.25	—100	38	GL-6942
	Water and Forced-air	0.565	3200	0.35	1.12	1.2	3000	0.25	—100	38	GL-6019
		1.250	4500	0.80	3.60	3.0	4000	0.570	—80	100	GL-6182

* Synchronizing-level conditions per tube.

† Grounded-grid operation.

TELEVISION CAMERA TUBES

Classification	Use	Focus and Deflection	Image Size, Inches	Maximum Photo-cathode Voltage	Maximum Anode Voltage	Maximum Signal Electrode Voltage	Cathode		Tube Type
							Volts	Amperes	
Image Orthicons	Studio and Outdoor Pick-up	Magnetic	1.8 Diagonal	—550	1350	—	6.3	0.6	GL-5820
	Low-light Pick-up	Magnetic	1.8 Diagonal	—550	1350	—	6.3	0.6	GL-6849

MAGNETRONS

Fixed Frequency

Classification	Frequency, Megacycles	Power Output	Nominal Anode		Tube Type
			Volts	Amperes	
Pulsed	2750–2860	4500 KW Peak	71,000 Peak	130 Peak	GL-6410 (Integral Magnet)

☐ VOLTAGE-TUNABLE MAGNETRONS, PACKAGED

Frequency, Megacycles	Power Output, Watts	Nominal Anode		Tube Type
		Volts	Milliamperes	
2200–3850	2.0 (minimum)	900–1600	10–20	GL-7398

KLYSTRONS

Classification	Operation	Frequency Range, Megacycles	Power Output, Kilowatts			Max Beam Voltage, Kilovolts	Max Beam Current, Amperes	Driving Power, Watts		Tube Type
			Saturation Level	Sync Level	Pedestal Level			Sync Level	Pedestal Level	
Three-Resonator, Tunable	CW, Electro-magnetic Focus	470–530	15	12	6.75	18	3	25	12	GL-6237
		530–584	15	12	6.75	18	3	25	12	GL-6238
		584–656	15	12	6.75	18	3	25	12	GL-6239
		656–722	15	12	6.75	18	3	25	12	GL-6240
		722–806	15	12	6.75	18	3	25	12	GL-6241
		806–890	15	12	6.75	18	3	25	12	GL-6242
	Pulsed, Electro-static Focus	960–1215	22 (Peak)	..	....	20 (Peak)	9.35 (Peak)	..	..	GL-6625

† Supersedes pages 5 and 6 dated 5-58.

□ Denotes an addition.

DIODES**Rectifiers**

Classification	Anode*			Cathode		Tube Type
	Average Amperes	Peak Amperes	Peak Inverse Volts	Volts	Amperes	
Half-wave, Mercury Vapor	5.0	20.0	20,000	5.0	19.0	GL-869-B
	10.0	40.0	22,000	5.0	30.0	GL-857-B
	75.0	450	16,000	5.0	65.0	GL-870-A
Half-wave, High Vacuum	1.25	5.0	75,000	16.0	19.1	GL-5973

UHF Diodes

1500 Megacycles	0.02	0.7	300	6.3	0.75	GL-2B22
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* Values listed are maximum values and do not apply for all types of application. Refer to data sheet for detailed information.

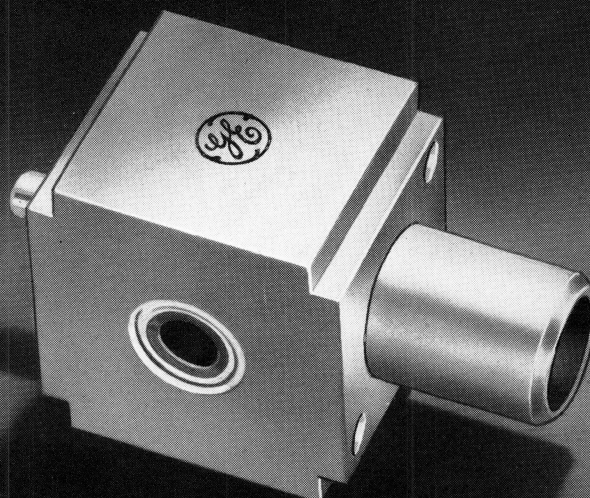
REFERENCE CAVITIES**Fixed Frequency**

Resonant Frequency, Megacycles	Incident Peak Power, Kilowatts	Max Frequency Deviation from -40 C to +100 C, Megacycles	Insertion Loss, Decibels		Loaded Q		Tube Type
			Min	Max	Min	Max	
9269.7-9270.3	5	± 0.4	5	8	1000	1500	GL-6301
9279.7-9280.3	5	± 0.4	5	8	1000	1500	GL-1Q26-A
9349.7-9350.3	5	± 0.4	4 (Bogey)	6	1500	2000	GL-6452

GAS-DISCHARGE DEVICES**Switching Tubes for Duplexers**

Frequency, Megacycles	Transmitter Peak Power, Megawatts	Min Peak Firing Power, Kilowatts	Max Recovery Time, Microseconds	Tube Type
2700-2900	2.5	250	25	GL-6619
	5.0	250	50	GL-6621
3400-3600	1.5	250	40	GL-6620

ELECTRONIC COMPONENTS DIVISION
GENERAL  ELECTRIC
 Schenectady 5, N. Y.



REFERENCE CAVITY

**5 KILOWATTS
PRESSURIZED**

9280 MEGACYCLES

**TRANSMISSION TYPE
FIXED FREQUENCY**

The GL-1Q26-A is a fixed-frequency, transmission-type, vacuum-sealed reference cavity for use as a frequency-determining reference at 9280 megacycles.

Particular advantages of this cavity are its

ability to operate from room temperature to -40°C with a maximum drift in resonant frequency of only plus or minus 0.4 megacycle and the fact that it can be used in a pressurized system.

TECHNICAL INFORMATION

GENERAL

Electrical

	Minimum	Bogey	Maximum
Resonant Frequency.....	9279.7	9280.0	9280.3 Megacycles
Source and Load Voltage Standing Wave Ratio at Resonant Frequency.....			1.05
Loaded Q.....	1000	1250	1500
Insertion Loss at Resonant Frequency.....	5	6.5	8 Decibels

Mechanical

Ambient Temperature Range.....	-65 to $+100^{\circ}\text{C}$
Mounting Position—Any	
Net Weight, approximate.....	8 Ounces


Electronic
TUBE

GENERAL  ELECTRIC

TECHNICAL INFORMATION (CONT'D)

MAXIMUM RATINGS

Incident Peak Power 5 Kilowatts

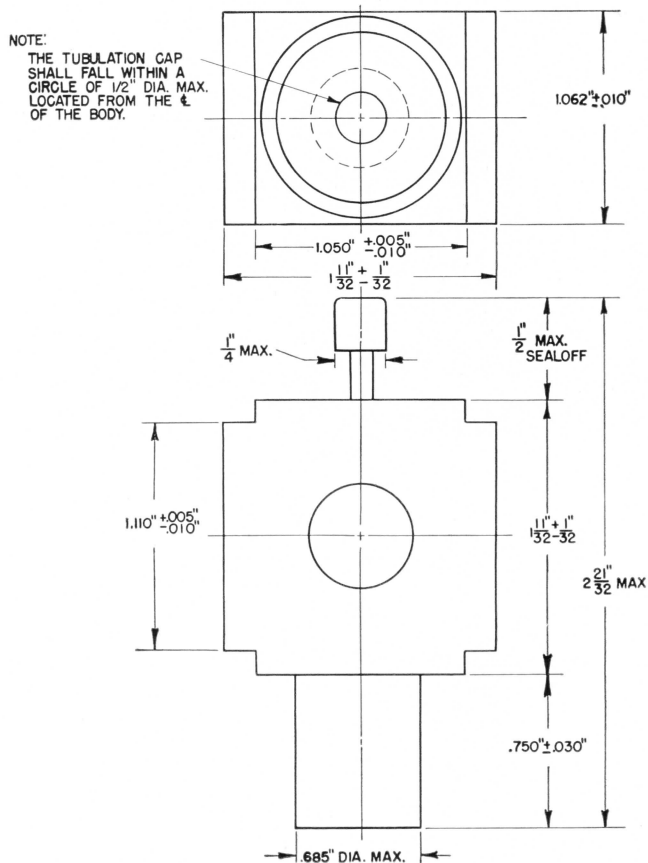
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Resonant-Frequency Shift from Value at 25 C

With Ambient Temperature

Room Temperature to 80 C ± 0.3 Max MegacyclesRoom Temperature to -40 C ± 0.4 Max MegacyclesRoom Temperature to -55 C ± 0.5 Max MegacyclesWith Vibration, 10 g's, 0.040" Displacement ± 0.1 Max Megacycles

With Ambient Pressure

15 to 45 Pounds per Square Inch Absolute ± 0.15 Max Megacycles15 Pounds per Square Inch Absolute to 100 Millimeters of Mercury Absolute ± 0.15 Max MegacyclesOUTLINE
GL-1Q26-A

N-24560AZ

5-4-54

TUBE DEPARTMENT

GENERAL  ELECTRIC

Schenectady 5, N. Y.



DIODE

The GL-2B22 is a high-perveance diode of the disk-seal type. It is used as a detector or monitor at frequencies up to 1500 megacycles.

TECHNICAL INFORMATION

GENERAL

Electrical Data

Cathode—Indirectly heated	
Heater voltage.....	6.3 volts
Heater current.....	0.75 ampere
Average characteristics	
Plate Voltage, $I_b = 20$ ma.....	6.0 volts
Direct Interelectrode Capacitance	
Cathode-plate.....	2.20 micromicrofarads

Mechanical Data

Type of cooling—Convection	
Maximum seal temperature.....	200 C
Base description.....	6-pin Octal
Mounting position—Any	
Net weight, approximate.....	3 ounces
Shipping weight, approximate.....	3 pounds


Electronic
TUBE

GENERAL  ELECTRIC

TECHNICAL INFORMATION (CONT'D)

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

DETECTOR

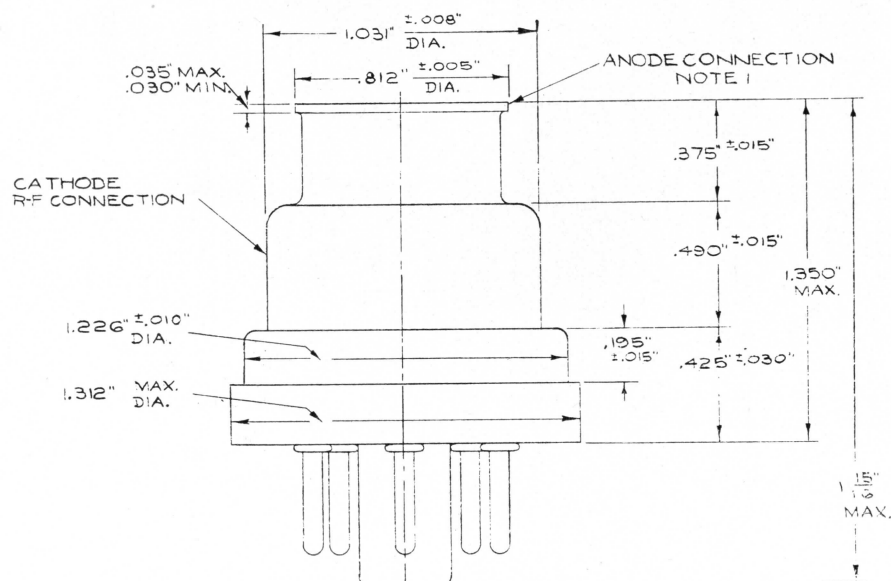
Maximum Ratings

Peak plate voltage.....	100	*volts
Peak cathode current.....	0.7	*ampere
Peak inverse voltage.....	300	volts
Average cathode current.....	20	milliamperes
Output voltage.....	150	volts d-c

Typical Operation

Average cathode current.....	5	milliamperes
Output voltage.....	50	volts d-c
Load resistance.....	10000	ohms

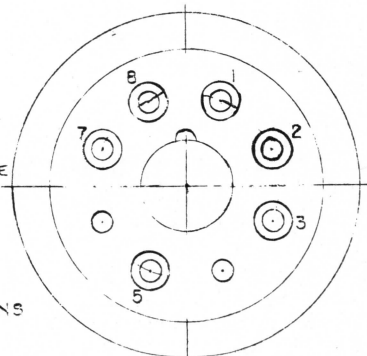
* Tubes shall not operate more than 5 microseconds in a 100-microsecond interval.



NOTE 1
GLASS WILL NOT
PROTRUDE BEYOND
EDGE OF ANODE
CONNECTION

NOTE 2
MAX. ECCENTRICITY
OF THE ϕ OF THE ANODE
CONNECTION WITH THE
 ϕ OF THE R-F CATHODE
.020"

NOTE 3
EXPOSED METAL PARTS
PLATED WITH 100 MSI
SILVER EXCEPT BASE PINS



PIN

CONNECTION

- | | |
|------------------------|------------|
| 1. INTERNAL CONNECTION | 5. CATHODE |
| 2. HEATER | 7. HEATER |
| 3. CATHODE | 8. CATHODE |

K-9033818

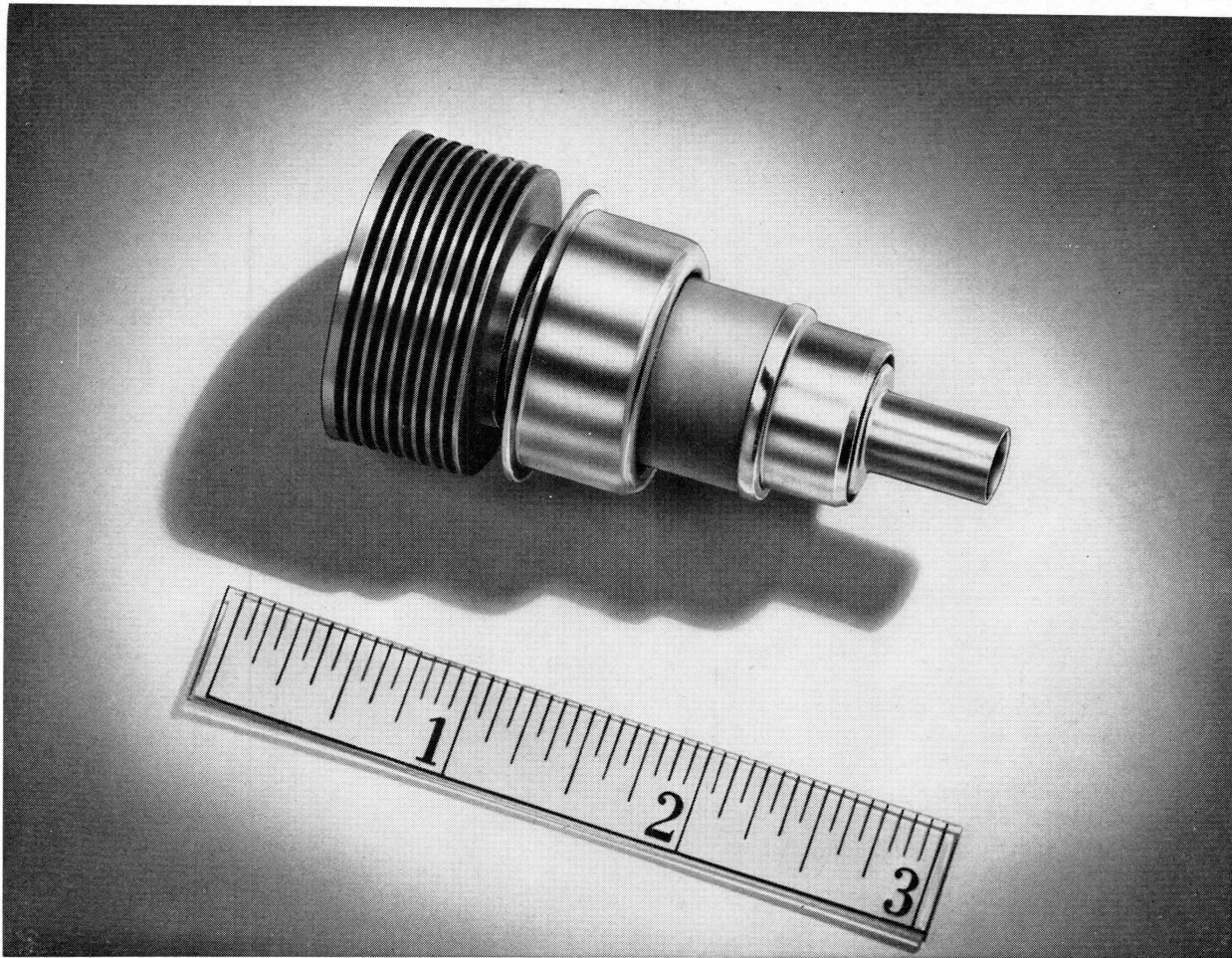
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OUTLINE GL-2B22
TUBE DEPARTMENT

GENERAL  ELECTRIC

Schenectady 5, N. Y.

PRINTED
IN
U.S.A.



TRIODE

UHF-VHF

17 WATTS OUTPUT AT 2500 MEGACYCLES

DISK-SEAL CONSTRUCTION

FORCED-AIR COOLED

METAL AND CERAMIC

INTEGRAL RADIATOR

The GL-2C39-B is a high- μ triode for use at very-high and ultra-high-frequencies in grounded-grid class C power-amplifier, oscillator, or frequency-multiplier circuits. In such service it will operate from the low frequencies to those as high as 2500 megacycles. The anode can dissipate 100 watts with forced-air cooling of the radiator through a suitable cowling. Cooling of the tube envelope is accomplished by conduction from the contact circuit members with sufficient additional forced air to limit the maximum temperature to 250 C.

The tube has an oxide-coated indirectly heated cathode, is of planar-electrode construction, and

has a metal-and-ceramic envelope. Graduated-diameter disk seals, typical of the General Electric lighthouse tube, assure maximum efficiency in the use of cavity and parallel-line circuits with the resultant desirable features of both low lead inductances and electrode isolation. Radio-frequency losses in the tube are kept to a minimum by the special techniques and materials used. Other features of the tube are the high transconductance and low interelectrode capacitances.

The GL-2C39-B is unilaterally interchangeable, both mechanically and electrically, with the GL-2C39-A but has a greater resistance to shock and vibration than that tube.

GENERAL  ELECTRIC

Supersedes ET-T1054 dated 2-54

TECHNICAL INFORMATION

GENERAL

Electrical

Cathode—Indirectly Heated	
Heater Voltage, dependent upon operating conditions†	6.3 Volts
Heater Current	1.0 Amperes
Cathode Heating Time, minimum	1.0 Minutes
Amplification Factor	100
Transconductance, $I_p = 70$ milliamperes, $E_p = 600$ volts	24,000 Micromhos
Direct Interelectrode Capacitances,	
With external shield, heater voltage = 0 volts	
Grid to Plate	1.90 $\mu\mu\text{f}$
Grid to Cathode	7.0 $\mu\mu\text{f}$
Plate to Cathode, maximum	0.035 $\mu\mu\text{f}$
Frequency for Maximum Ratings	2500 Megacycles

Mechanical

Mounting Position—Any	
Only Anode Flange To Be Used As a Socket Stop and Clamp	
Net Weight, approximate	2 Ounces

Thermal

Cooling	
Anode and Anode Seal—Conduction and Forced Air	
Grid and Cathode Seals—Conduction and Forced Air	
□ Recommended Air Flow Cowling—157-JAN	
Recommended Air Flow on Anode Radiator at Sea Level	
Incoming Air Temperature 25 C, plate dissipation 100 watts	12.5 Cubic Feet per Minute
⊕ Maximum Temperature of Any Seal Under Any Condition*	250 C

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

Key-Down Conditions Per Tube Without Amplitude Modulation

Maximum Ratings, Absolute Values

Heater Voltage, dependent upon operating conditions†	
DC Plate Voltage	1000 Volts
DC Cathode Current	125 Milliamperes
DC Grid Voltage	—150 Volts
DC Grid Current	50 Milliamperes
Peak Positive RF Grid Voltage	30 Volts
Peak Negative RF Grid Voltage	—400 Volts
Plate Dissipation	100 Watts
Grid Dissipation	2 Watts

Typical Operation—Key-Down Conditions

Class C Oscillator, grid-return circuit	
Frequency	500 2500 Megacycles
DC Plate Voltage	900 900 Volts
DC Plate Current	90 90 Milliamperes
DC Grid Current	30 27 Milliamperes
DC Grid Voltage	—40 —22 Volts
Heater Voltage†	
Useful Power Output	40 17 Watts

RADIO-FREQUENCY POWER AMPLIFIER OR OSCILLATOR, PLATE-MODULATED—CLASS C TELEPHONY

Carrier Conditions For Use With A Maximum Modulation Factor Of 1.0

Maximum Ratings, Absolute Values

Heater Voltage, dependent upon operating conditions†	
DC Plate Voltage†	600 Volts
DC Cathode Current	100 Milliamperes
DC Grid Voltage	—150 Volts
DC Grid Current	50 Milliamperes

TECHNICAL INFORMATION (CONT'D)

Peak Positive RF Grid Voltage.....	30 Volts
Peak Negative RF Grid Voltage.....	-400 Volts
Plate Dissipation.....	70 Watts
Grid Dissipation.....	2 Watts

* Where long and reliable operation are important, lower tube envelope temperatures should be used.

† The GL-2C39-B operates at frequencies where it is necessary to consider transit-time effects of the electron current. The principal effects influencing tube operation are the decrease in power output and operating efficiency with increase in frequency, and the bombardment and heating of the cathode by electrons from the region of the grid which can be severe enough to result in short tube life and erratic operation. Operating frequency, circuit design and adjustment, grid bias, and grid current contribute to the degree of cathode bombardment. There is an optimum heater voltage which will maintain the cathode at the correct operating temperature for a particular set of operating conditions.

If the conditions of operation result in appreciable cathode back heating, it may be necessary to start dynamic tube operation at normal heater voltage followed by a reduction of heater voltage to the proper value. A maximum variation of plus or minus five percent in heater voltage is recommended where extended tube life is a factor. Under all other conditions, the variation in heater voltage should not exceed plus or minus ten percent. For applications above 400 megacycles, recommendations are to be obtained from the tube manufacturer regarding the heater voltage to be used under a specific set of operating conditions.

‡ For modulation factors less than 1.0 a higher d-c plate voltage may be used if the sum of the peak positive audio voltage and the d-c plate voltage does not exceed 1200 volts.

□ Denotes an addition.

⊕ Denotes a change.

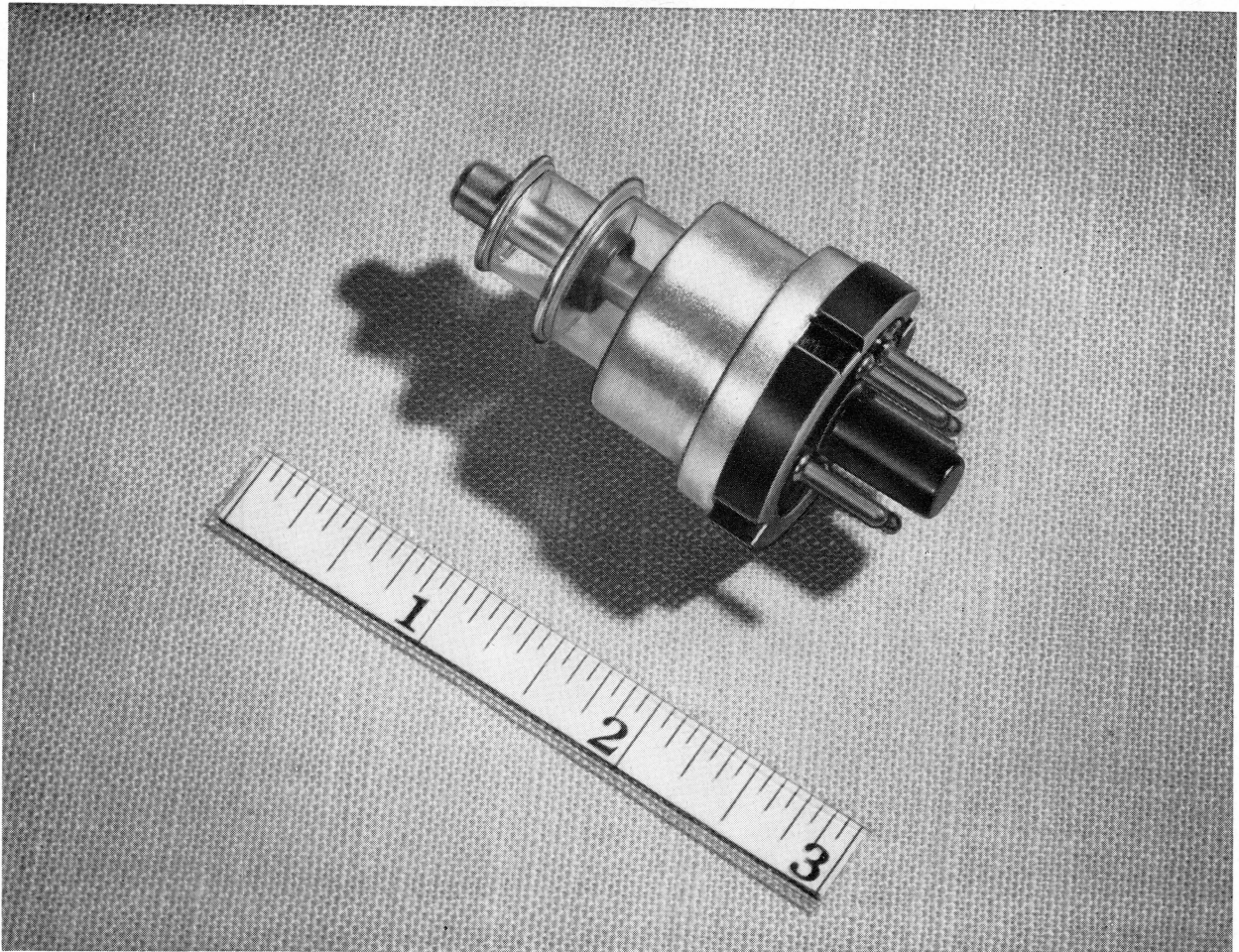
9-57



1. External metal parts (except radiator) plated with 30 msi of copper and/or silver.
2. Solder not to extend radially beyond grid RF terminal.
- ⊕ 3. Total indicated runout of the grid-contact surface and the cathode-contact surface with respect to the anode shall not exceed 0.020".
- ⊕ 4. Total indicated runout of the cathode-contact surface with respect to the heater-contact surface shall not exceed 0.012".
5. Only this flange to be used as a socket stop and clamp.

8-29-57

PRINTED
IN
U.S.A.



TRIODE

SMALL SIZE

LIGHTHOUSE TYPE

LOW IMPEDANCE

SINGLE-ENDED

The GL-2C40 is a triode of lighthouse construction for use as a Class A radio-frequency amplifier or CW oscillator at frequencies as high as 3370 megacycles.

The radio-frequency cathode connection is made through a disk-type capacitor which is incorporated

in the tube. This results in a low-impedance radio-frequency path from the cathode to the external circuit.

The envelope construction results in low losses, provides convenient electrode contact surfaces, and enables the tube to fit easily into coaxial circuits.

GENERAL  ELECTRIC

Supersedes ETX-123, dated 5-46

TECHNICAL INFORMATION

GENERAL

Electrical

Cathode—Indirectly Heated				
Heater Voltage		6.3 $\pm$ 5%		Volts
Heater Current		0.75		Amperes
☐ Heater Heating Time*		6.0		Seconds
☐ Cathode Heating Time†		1.0		Minutes
Average Characteristics				
E _b = 250 volts, R _k = 200 ohms, C _k = 1000 microfarads				
☐ Amplification Factor	27	36	44	
Transconductance	4400	4850	5700	Micromhos
☐ Plate Current	13	17	22	Milliamperes
Direct Interelectrode Capacitances				
Grid to Plate	1.15	1.3	1.40	$\mu\mu\text{f}$
Grid to Cathode				
E _f = 0 volts	1.90	2.1	2.35	$\mu\mu\text{f}$
☐ E _f = 6.3 volts		2.75		$\mu\mu\text{f}$
Plate to Cathode, maximum			0.03	$\mu\mu\text{f}$
Cathode RF Connection to Cathode	30	100	200	$\mu\mu\text{f}$
Frequency			3370	Megacycles

Mechanical

Base—6-Pin Octal, B6-108				
Mounting Position—Any				
⊕ Net Weight, approximate		1.2		Ounces

Thermal

Type of Cooling—Convection and Conduction				
⊕ Maximum Seal Temperature		175		C

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS‡

CW OSCILLATOR OR AMPLIFIER§

Maximum Ratings, Absolute Values

DC Plate Voltage	500	Max	Volts
DC Plate Current	25	Max	Milliamperes
☐ DC Grid Voltage	-50	Max	Volts
☐ DC Grid Current	8	Max	Milliamperes
☐ Heater-Cathode Voltage			
Heater Positive with Respect to Cathode	90	Max	Volts
Heater Negative with Respect to Cathode	90	Max	Volts
☐ Cathode Shell Voltage			
Cathode Shell Positive	90	Max	Volts
Cathode Shell Negative	90	Max	Volts
Plate Dissipation	6.5	Max	Watts
Frequency	3370		Megacycles

CLASS A RADIO-FREQUENCY AMPLIFIER

Grid-Return Circuit

Typical Operation

DC Plate Voltage	250	Volts
DC Plate Current	17	Milliamperes
Cathode Bias Resistor	200	Ohms
⊕ Plate Input	4.25	Watts
Noise Figure, small signal//	8.5	Decibels
Power Gain, small signal	15	Decibels
Frequency	700	Megacycles

RADIO-FREQUENCY POWER OSCILLATOR—CLASS C TELEGRAPHY

Key-Down Conditions per Tube Without Amplitude Modulation

Typical Operation

Primarily Intended for Use as a Local Oscillator in the Frequency-Range of 100 to 3370 Megacycles

DC Plate Voltage	250	Volts
DC Grid Voltage, R _g = 10 kilohms	-5.0	Volts
DC Plate Current	20	Milliamperes
⊕ DC Grid Current, approximate	0.5	Milliamperes
Plate Power Output	0.075	Watts
Frequency	3370	Megacycles

* All other tubes in the same heater string should have the same heater heating time.

† Cathode heating time is zero minutes for CW operation at 250 volts or less.

‡ Voltages are measured with respect to cathode return.

§ Where long and reliable operation are important, these ratings should be reduced by 25 percent.

* Based on theoretical noise of 1KT Δ f.

□ Denotes an addition.

⊕ Denotes a change.

NOISE FIGURE VS FREQUENCY

(APPROXIMATE)

$E_f = 6.3$ VOLTS, $E_b = 250$ VOLTS, $R_k = 200$ OHMS

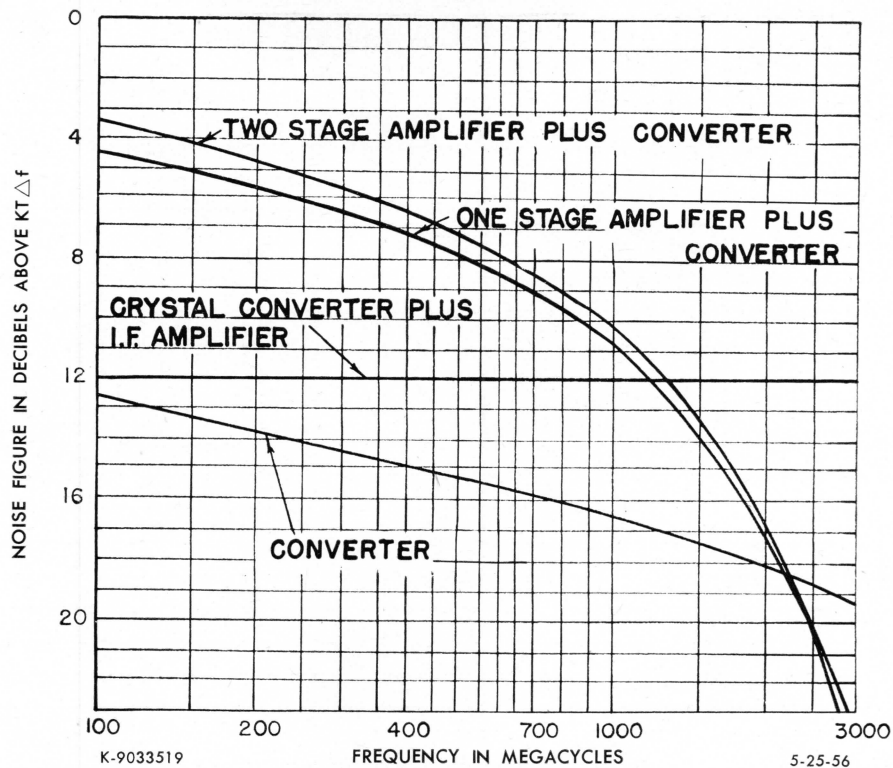
GRID SEPARATION CIRCUIT

GL-2C40

ET-T1461

Page 3

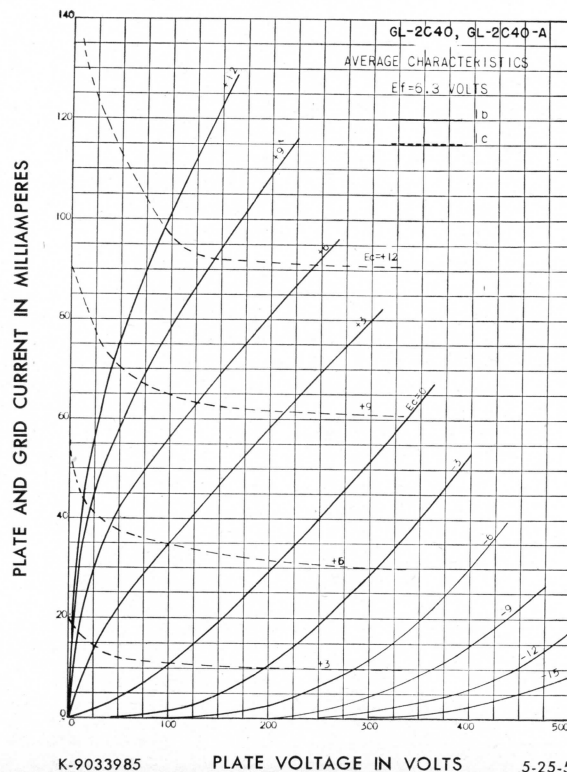
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AVERAGE CHARACTERISTICS

$E_f = 6.3$ VOLTS

— = I_b
- - - = I_c



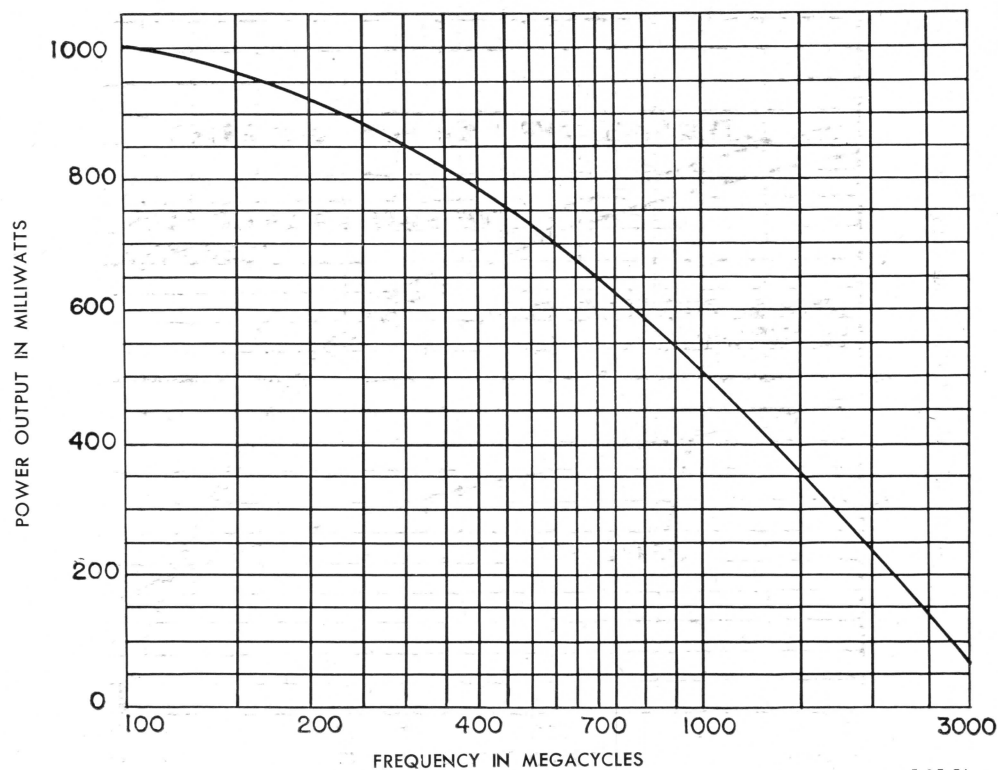
GL-2C40

ET-T1461

Page 4

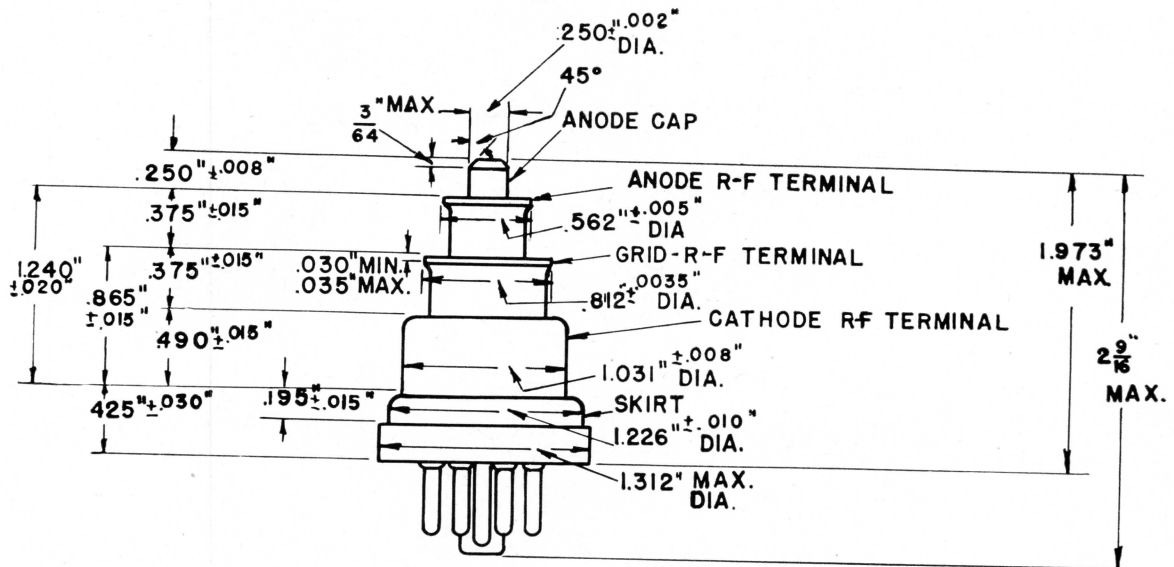
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POWER OUTPUT VS FREQUENCY (APPROXIMATE OSCILLATOR PERFORMANCE) $E_{bb} = 250$ VOLTS, $R_g = 10,000$ OHMS

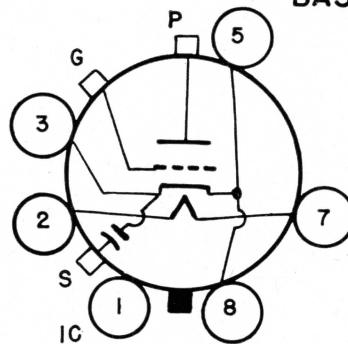


K-9033518

5-25-56



BASING DIAGRAM



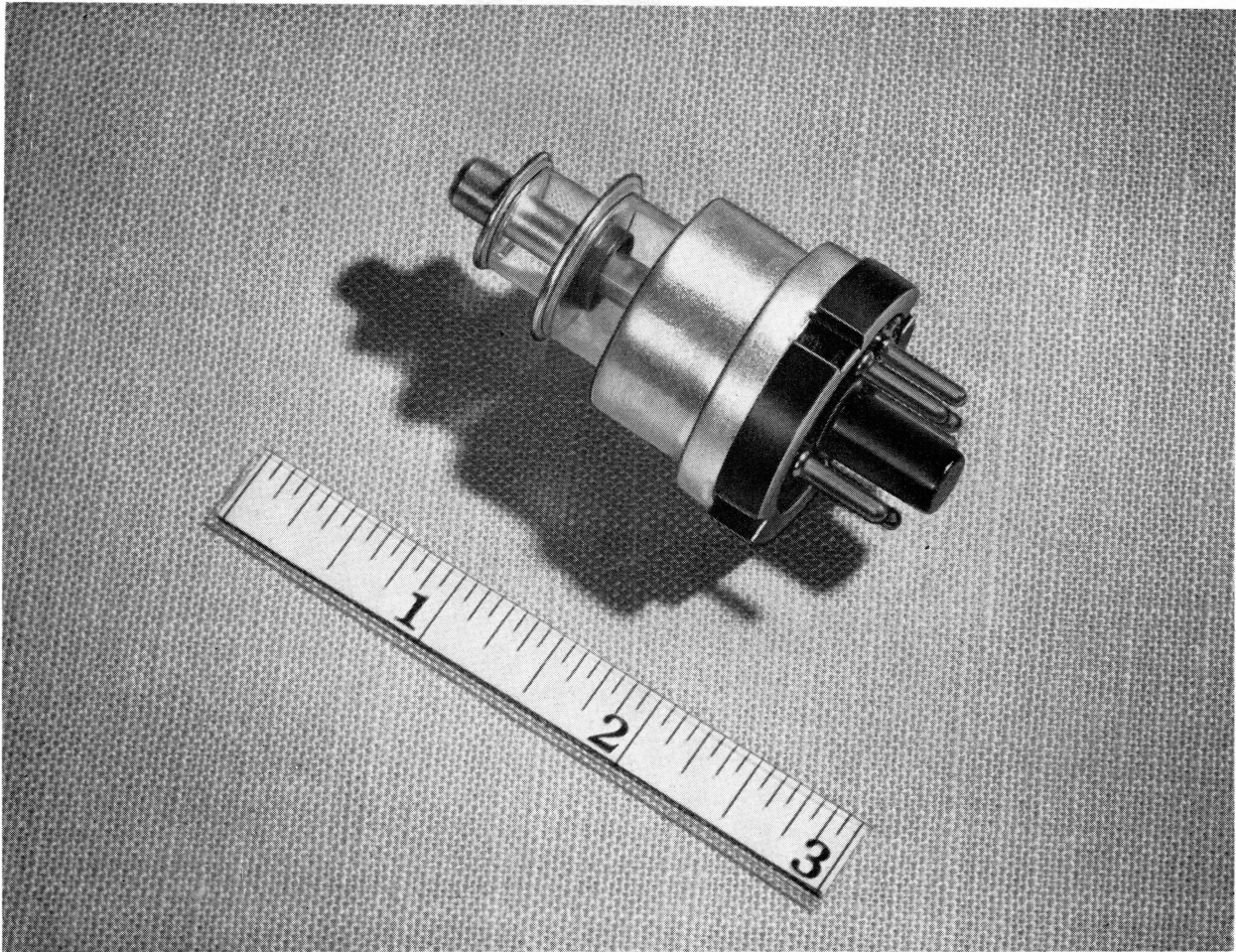
KEY

- PIN 1: INTERNAL CONNECTION. DO NOT USE
 PIN 2: HEATER
 PIN 3: CATHODE
 PIN 5: CATHODE
 PIN 7: HEATER
 PIN 8: CATHODE
 TOP CAP: PLATE
 DISC TERMINAL: GRID
 SHELL: CATHODE RF TERMINAL

NOTE:

- 1: GLASS SHALL NOT PROTRUDE BEYOND EDGE OF ANODE RF TERMINAL OR GRID RF TERMINAL.
- 2: EXPOSED METAL RF PARTS TO BE PLATED WITH 100 MSI SILVER EXCEPT BASE PINS.
- ⊕3: ANODE CAP AND GRID RF TERMINAL TO BE CONCENTRIC WITH RESPECT TO THE CATHODE RF TERMINAL WITHIN $\frac{1}{64}$ INCH (RUN-OUT OF $\frac{1}{32}$ INCH MAXIMUM).

ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
Schenectady 5, N. Y.



TRIODE

0.075 WATTS OUTPUT AT 3370 MEGACYCLES**LOW LOSS****LOW INTERELECTRODE CAPACITANCES****LIGHTHOUSE TYPE****LOW LEAD INDUCTANCE****SINGLE-ENDED**

The GL-2C40-A is a three-electrode tube of disk-seal construction for use as a Class A radio-frequency amplifier, Class C CW oscillator, or plate-pulsed oscillator.

The radio-frequency cathode connection is made through a disk-type capacitor which is incorporated

within the tube. The disk seals and parallel-plane structure result in very low lead inductance, low-interelectrode capacitances despite close spacings of the electrodes, and good radio-frequency isolation of the anode from the cathode. Silver-plated radio-frequency terminals assure low losses, and provide excellent contact to external circuitry.

GENERAL  ELECTRIC

Supersedes ET-T1212A dated 6-56

TECHNICAL INFORMATION

GENERAL

Electrical

Cathode—Indirectly Heated

Heater Voltage.....	6.3 ± 5%			Volts
Heater Current.....	0.75			Amperes
□ Heater Heating Time*.....	6.0			Seconds
□ Cathode Heating Time†.....	1.0			Minutes
Average Characteristics	Minimum	Bogey	Maximum	
E _b = 250 volts, R _k = 200 ohms, C _k = 1000 microfarads				
Amplification Factor.....	27	35	44	
Transconductance.....	4400	5100	5700	Micromhos
Plate Current.....	13	17	22	Milliamperes
Direct Interelectrode Capacitances				
Grid to Plate.....	1.15	1.3	1.40	μμf
Grid to Cathode				
E _f = 0 volts.....	1.90	2.15	2.35	μμf
E _f = 6.3 volts.....		2.75		μμf
Plate to Cathode, E _f = 0 volts.....		0.02	0.03	μμf
Cathode RF Connection to Cathode.....	30	100	200	μμf
Frequency.....			3370	Megacycles

Mechanical

Base—Small H-Wafer, 6-Pin Octal, B6-108

Mounting Position—Any

Net Weight, approximate..... 1.2 Ounces

Thermal

Type of Cooling—Convection and Conduction

Maximum Seal Temperature..... 175 C

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS‡

CW OSCILLATOR OR AMPLIFIER§

Maximum Ratings, Absolute Values

DC Plate Voltage.....	500 Max	Volts
DC Plate Current.....	25 Max	Milliamperes
☐ DC Grid Voltage.....	—50 Max	Volts
☐ DC Grid Current.....	.8 Max	Milliamperes
Heater-Cathode Voltage		
Heater Positive with Respect to Cathode.....	90 Max	Volts
Heater Negative with Respect to Cathode.....	90 Max	Volts
Cathode Shell Voltage		
Cathode Shell Positive.....	90 Max	Volts
Cathode Shell Negative.....	90 Max	Volts
Plate Dissipation.....	6.5 Max	Watts
Frequency.....	3370	Megacycles

CLASS A RADIO-FREQUENCY AMPLIFIER

Grid-Return Circuit

Typical Operation

DC Plate Voltage.....	250	Volts
DC Plate Current.....	17	Milliamperes
Cathode Bias Resistor.....	200	Ohms
⊕Plate Input.....	4.25	Watts
Noise Figure, small signal||.....	8.5	Decibels
Power Gain, small signal.....	15	Decibels
Frequency.....	700	Megacycles

TECHNICAL INFORMATION (CONT'D)

RADIO-FREQUENCY POWER OSCILLATOR—CLASS C TELEGRAPHY

Key-Down Conditions per Tube Without Amplitude Modulation

Typical Operation

DC Plate Voltage.....	250	Volts
DC Grid Voltage, $R_g = 10$ kilohms.....	-5.0	Volts
DC Plate Current.....	20	Milliamperes
⊕DC Grid Current, approximate.....	0.5	Milliamperes
Plate Input.....	5	Watts
Power Output, useful.....	0.075	Watts
Frequency.....	3370	Megacycles

PLATE-PULSED POWER OSCILLATOR†

Maximum Ratings, Absolute Values

Peak Plate Voltage.....	1400 Max	Volts
Peak Grid Voltage.....	-100 Max	Volts
Peak Plate Current.....	2.0 Max	Amperes
Average Plate Current.....	3.0 Max	Milliamperes
Peak Grid Current.....	1.0 Max	Amperes
Average Grid Current.....	1.5 Max	Milliamperes
Grid Bias, $R_k, R_g = 0$	0 Max	Volts
Pulse Width.....	1.5 Max	Microseconds
Duty Factor.....	0.002	
Heater-Cathode Voltage		
Heater Positive with Respect to Cathode.....	90 Max	Volts
Heater Negative with Respect to Cathode.....	90 Max	Volts
Cathode Shell Voltage		
Cathode Shell Positive.....	90 Max	Volts
Cathode Shell Negative.....	90 Max	Volts
Plate Dissipation.....	4.0 Max	Watts
Frequency.....	3370	Megacycles

Typical Operation

Peak Plate Voltage.....	1400	Volts
Peak Plate Current.....	1.0	Amperes
Pulse Width.....	1.0	Microseconds
Duty Factor.....	0.001	
Power Output, useful average.....	0.3	Watts
Peak Power Output, useful.....	300	Watts
Frequency.....	3000	Megacycles

* All other tubes in the same heater string should have the same heater heating time.

† Cathode heating time is zero minutes for CW operation at 250 volts or less.

‡ Voltages are measured with respect to cathode return.

§ Where long and reliable operation are important, these ratings should be reduced by 25 percent.

|| Based on theoretical noise of $1KT\Delta f$.

¶ Tube shall not be pulse operated for more than ten microseconds in any 5000-microsecond interval. Grid-pulsed operation is limited to the CW oscillator ratings.

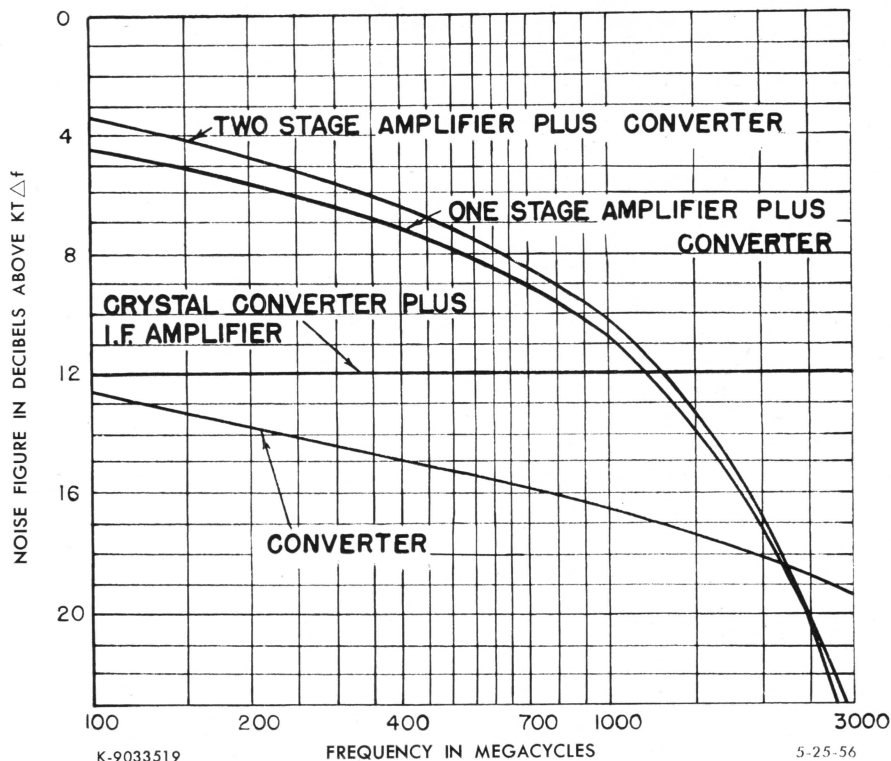
□ Denotes an addition.

⊕ Denotes a change.

NOISE FIGURE VS FREQUENCY

(APPROXIMATE)

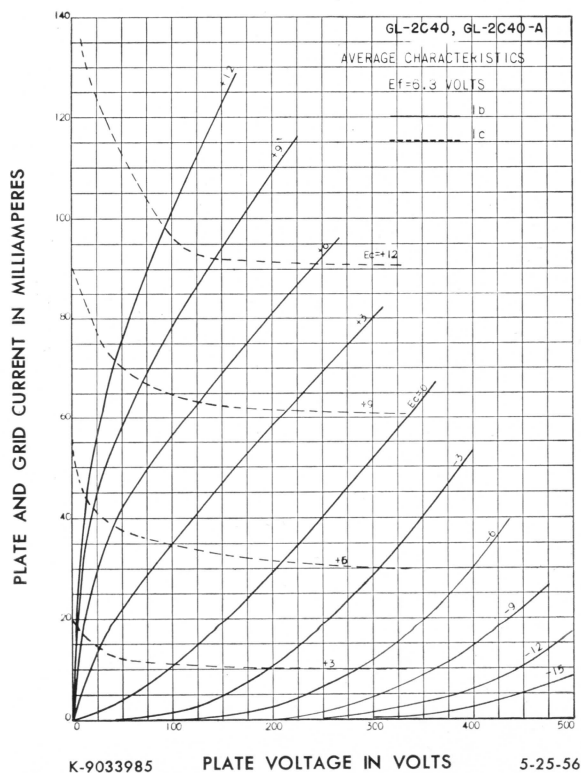
$E_f = 6.3$ VOLTS, $E_b = 250$ VOLTS, $R_k = 200$ OHMS
GRID SEPARATION CIRCUIT



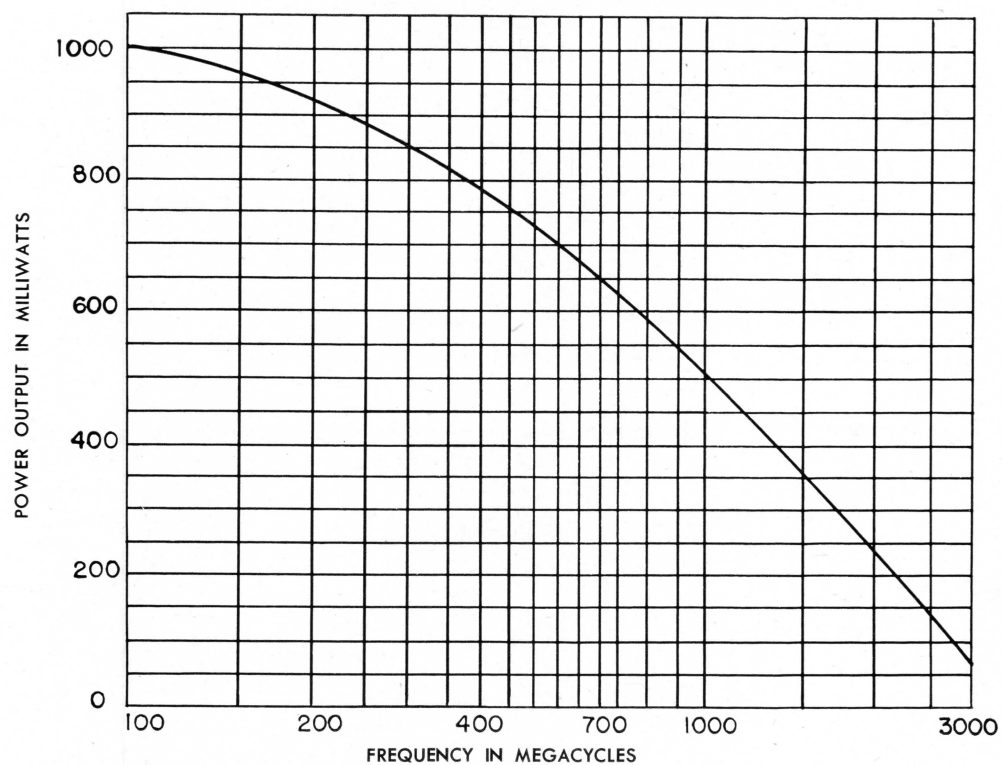
AVERAGE CHARACTERISTICS

$E_f = 6.3$ VOLTS

— = I_b
--- = I_c

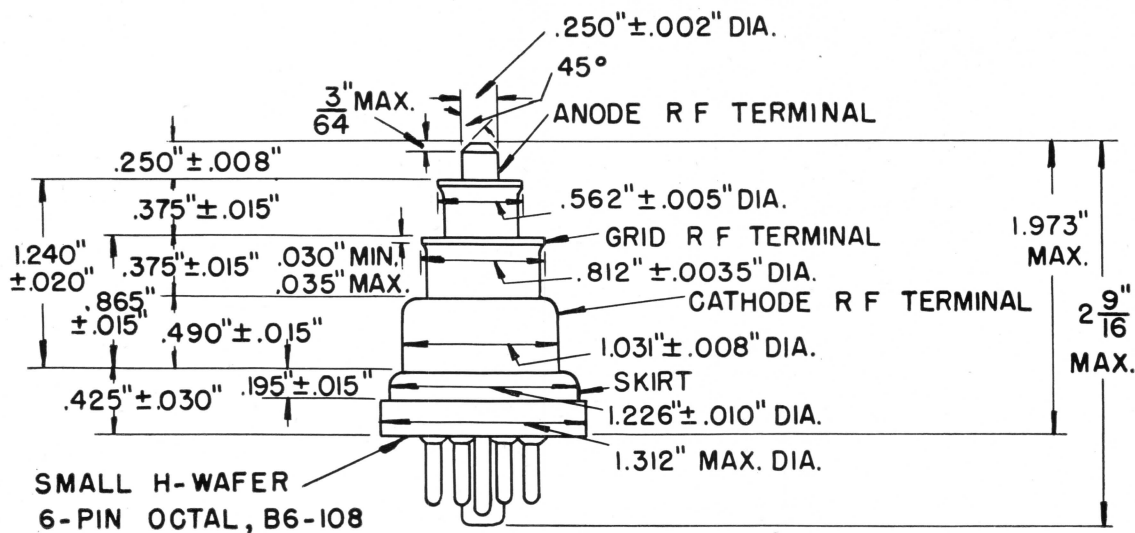


POWER OUTPUT VS FREQUENCY
(APPROXIMATE OSCILLATOR PERFORMANCE)
 $E_{bb} = 250$ VOLTS, $R_g = 10,000$ OHMS

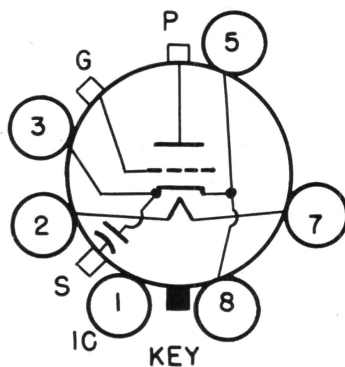


K-9033518

5-25-56



BASING DIAGRAM



NOTE:

- 1: GLASS SHALL NOT PROTRUDE BEYOND EDGE OF ANODE R F TERMINAL OR GRID R F TERMINAL.
- 2: ANODE CAP AND GRID R F TERMINAL TO BE CONCENTRIC WITH RESPECT TO THE CATHODE R F TERMINAL WITHIN $\frac{1}{64}$ INCH (RUN-OUT OF $\frac{1}{32}$ INCH, MAXIMUM).

K-69087-72A703

6-22-55

ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
 Schenectady 5, N. Y.



TRIODE

SMALL SIZE

LIGHTHOUSE TYPE

LOW IMPEDANCE

SINGLE-ENDED

The GL-2C43 is a triode of lighthouse construction for use as a Class C radio-frequency amplifier or pulsed oscillator at frequencies as high as 3370 megacycles.

The radio-frequency cathode connection is made through a disk-type capacitor which is incorporated

in the tube. This results in a low-impedance radio-frequency path from cathode to the external circuit.

The envelope construction results in low losses, provides convenient electrode contact surfaces, and enables the tube to fit easily into coaxial circuits.

GENERAL  ELECTRIC

Supersedes ETX-124 dated 12-56

TECHNICAL INFORMATION

GENERAL

Electrical

Cathode—Indirectly Heated

Heater Voltage*	6.3 ± 5%	Volts
-----------------	----------	-------

Heater Current	0.9	Amperes
----------------	-----	---------

□ Heater Heating Time†	6.0	Seconds
------------------------	-----	---------

□ Cathode Heating Time‡	1.0	Minutes
-------------------------	-----	---------

□ Heater-Cathode Voltage

Heater Positive with Respect to Cathode	90 Max	Volts
---	--------	-------

Heater Negative with Respect to Cathode	90 Max	Volts
---	--------	-------

□ Cathode-Shell Voltage

Cathode Shell Positive	90 Max	Volts
------------------------	--------	-------

Cathode Shell Negative	90 Max	Volts
------------------------	--------	-------

Average Characteristics

Minimum	Bogey	Maximum
---------	-------	---------

$E_b = 250$ volts, $R_k = 100$ ohms, $C_k = 1000$ microfarads		
---	--	--

Amplification Factor	30	48	70
----------------------	----	----	----

Transconductance	6200	8000	10,000	Micromhos
------------------	------	------	--------	-----------

□ Plate Current	13	21	32	Milliamperes
-----------------	----	----	----	--------------

Direct Interelectrode Capacitances

Grid to Plate	1.50	1.7	1.90	$\mu\mu\text{f}$
---------------	------	-----	------	------------------

Grid to Cathode

$E_f = 0$ volts	2.35	2.9	3.25	$\mu\mu\text{f}$
-----------------	------	-----	------	------------------

□ $E_f = 6.3$ volts		3.4		$\mu\mu\text{f}$
---------------------	--	-----	--	------------------

⊕ Plate to Cathode, maximum			0.05	$\mu\mu\text{f}$
-----------------------------	--	--	------	------------------

Cathode RF Connection to Cathode	30	100	200	$\mu\mu\text{f}$
----------------------------------	----	-----	-----	------------------

Frequency			3370	Megacycles
-----------	--	--	------	------------

Mechanical

Base—6-Pin Octal, B6-108

Mounting Position—Any

⊕ Net Weight, approximate	1.0	Ounces
---------------------------	-----	--------

Thermal§

Type of Cooling—Convection and Conduction

⊕ Maximum Seal Temperature	175	C
----------------------------	-----	---

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS§//
CW OSCILLATOR AND CLASS C RADIO-FREQUENCY POWER AMPLIFIER

Maximum Ratings, Absolute Values—Ratings are per Tube

DC Plate Voltage	500 Max	Volts
------------------	---------	-------

DC Plate Current	40 Max	Milliamperes
------------------	--------	--------------

Plate Dissipation	12 Max	Watts
-------------------	--------	-------

Cathode Current	55 Max	Milliamperes
-----------------	--------	--------------

Frequency	1500	Megacycles
-----------	------	------------

CW OSCILLATOR

Two Tubes in Push-Pull

Typical Operation

DC Plate Voltage	360	470	Volts
------------------	-----	-----	-------

DC Plate Current, total for both tubes	28	38	Milliamperes
--	----	----	--------------

Grid Leak Resistance	1000	1000	Ohms
----------------------	------	------	------

Plate Input	10	17.9	Watts
-------------	----	------	-------

Plate Dissipation	5.3	8.9	Watts
-------------------	-----	-----	-------

Power Output, approximate, total for both tubes	4.7	9.0	Watts
---	-----	-----	-------

Frequency	350	350	Megacycles
-----------	-----	-----	------------

POWER OSCILLATOR, PLATE PULSED*//

Maximum Ratings, Absolute Values—Ratings are per Tube

Peak Anode Voltage	3500 Max	Volts
--------------------	----------	-------

Peak Plate Current	2.75 Max	Amperes
--------------------	----------	---------

Average Cathode Current During Pulse	4.0 Max	Amperes
--------------------------------------	---------	---------

Plate Dissipation, average	12.0 Max	Watts
----------------------------	----------	-------

Duty Cycle	0.006	
------------	-------	--

Pulse Width	10 Max	Microseconds
-------------	--------	--------------

Frequency	3370	Megacycles
-----------	------	------------

TECHNICAL INFORMATION (CONT'D)

POWER OSCILLATOR, PLATE PULSED*//

Typical Operation—Ratings are per Tube

Peak Anode Voltage.....	3000	Volts
⊕DC Plate Current, average.....	2.5	Milliamperes
Grid Leak Resistance.....	100	Ohms
Peak Plate Current.....	2.5	Amperes
Plate Dissipation, average.....	6.0	Watts
⊕Peak Power Output.....	1750	Watts
Duty Cycle.....	0.001	
Pulse Width.....	1.0	Microseconds
Pulse Repetition Rate.....	1000	Pulses per Second
⊕Impedance Presented to Pulses, approximate.....	1200	Ohms
⊕Frequency.....	3370	Megacycles

CLASS C RADIO-FREQUENCY POWER AMPLIFIER, PLATE MODULATED

Carrier Conditions for use with a Modulation Factor of 1.0

GRID SEPARATION CIRCUIT

Two Tubes in Push-Pull

Typical Operation

DC Plate Voltage.....	350	Volts
DC Plate Current, total for both tubes.....	48	Milliamperes
DC Grid Voltage, $R_g = 1200$ ohms.....	-50	Volts
DC Grid Current, approximate, total for both tubes.....	40	Milliamperes
Plate Input.....	16.7	Watts
Plate Dissipation.....	6.7	Watts
Driving Power, approximate.....	3.0	Watts
Plate Power Output, total for both tubes.....	10.0	Watts
Frequency.....	300	Megacycles

FREQUENCY MULTIPLIER

Two Tubes in Push-Pull

Typical Operation

DC Plate Voltage.....	350	Volts
DC Plate Current, total for both tubes.....	50	Milliamperes
DC Grid Voltage, $R_g = 2700$ ohms.....	-80	Volts
DC Grid Current, approximate, total for both tubes.....	30	Milliamperes
Plate Input.....	17.5	Watts
Plate Dissipation.....	13.1	Watts
Driving Power, approximate.....	3	Watts
⊕Plate Power Output, approximate, total for both tubes.....	4.4	Watts
Output Frequency.....	300	Megacycles
Driving Frequency.....	100	Megacycles

* A heater voltage of 5.8 volts should be used for CW operation below 500 megacycles. For CW operation above 500 megacycles, the heater voltage is dependent upon circuit requirements.

† All other tubes in the same heater string should have the same heater heating time.

‡ Cathode heating time is zero minutes for CW operation at 250 volts or less.

§ Where long and reliable operation are important, these ratings should be reduced by 25 percent.

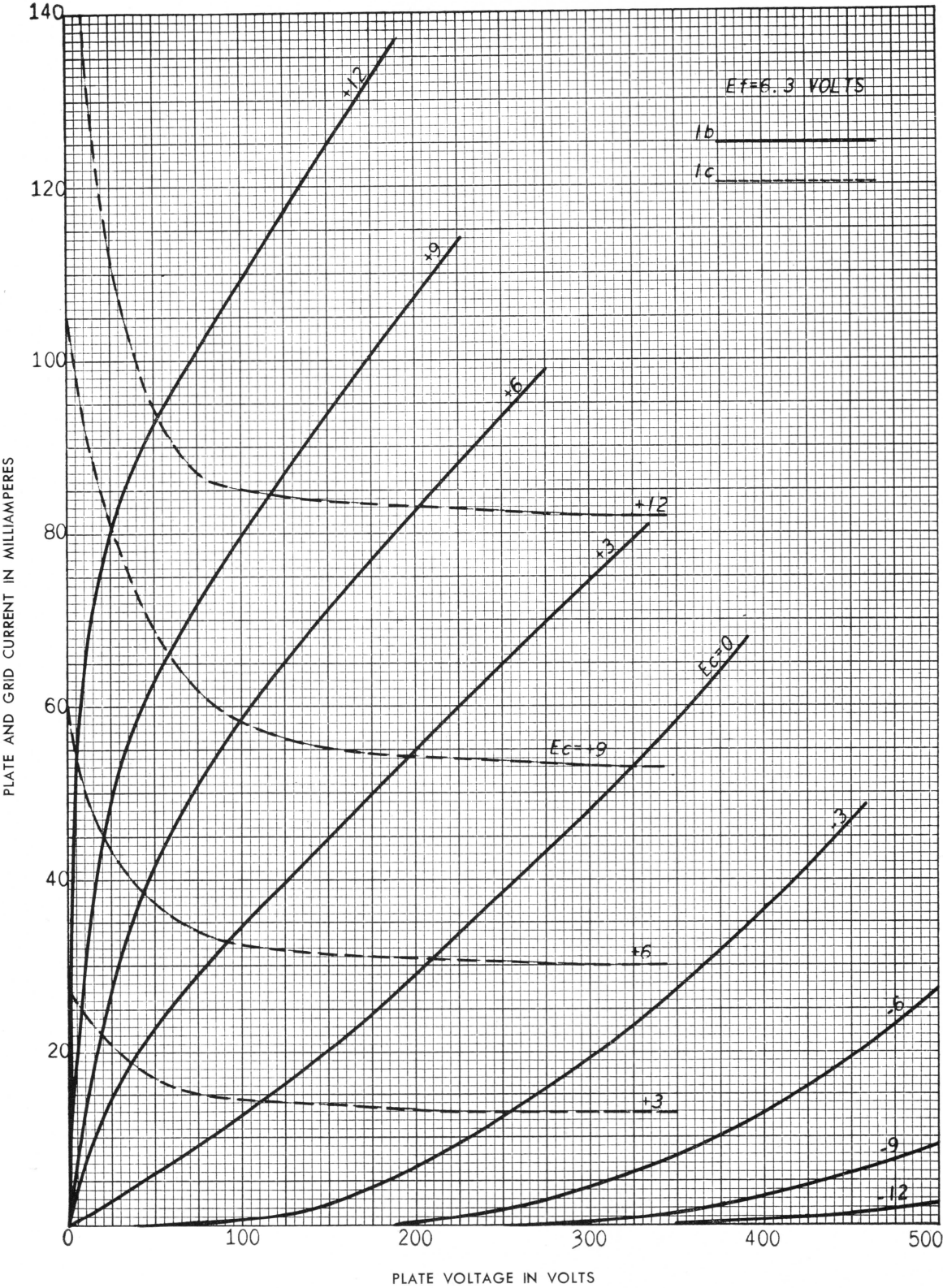
Voltag es are measured with respect to cathode return.

//Tube should not be grid pulsed beyond the CW ratings.

□ Denotes an addition.

⊕ Denotes a change.

AVERAGE CHARACTERISTICS



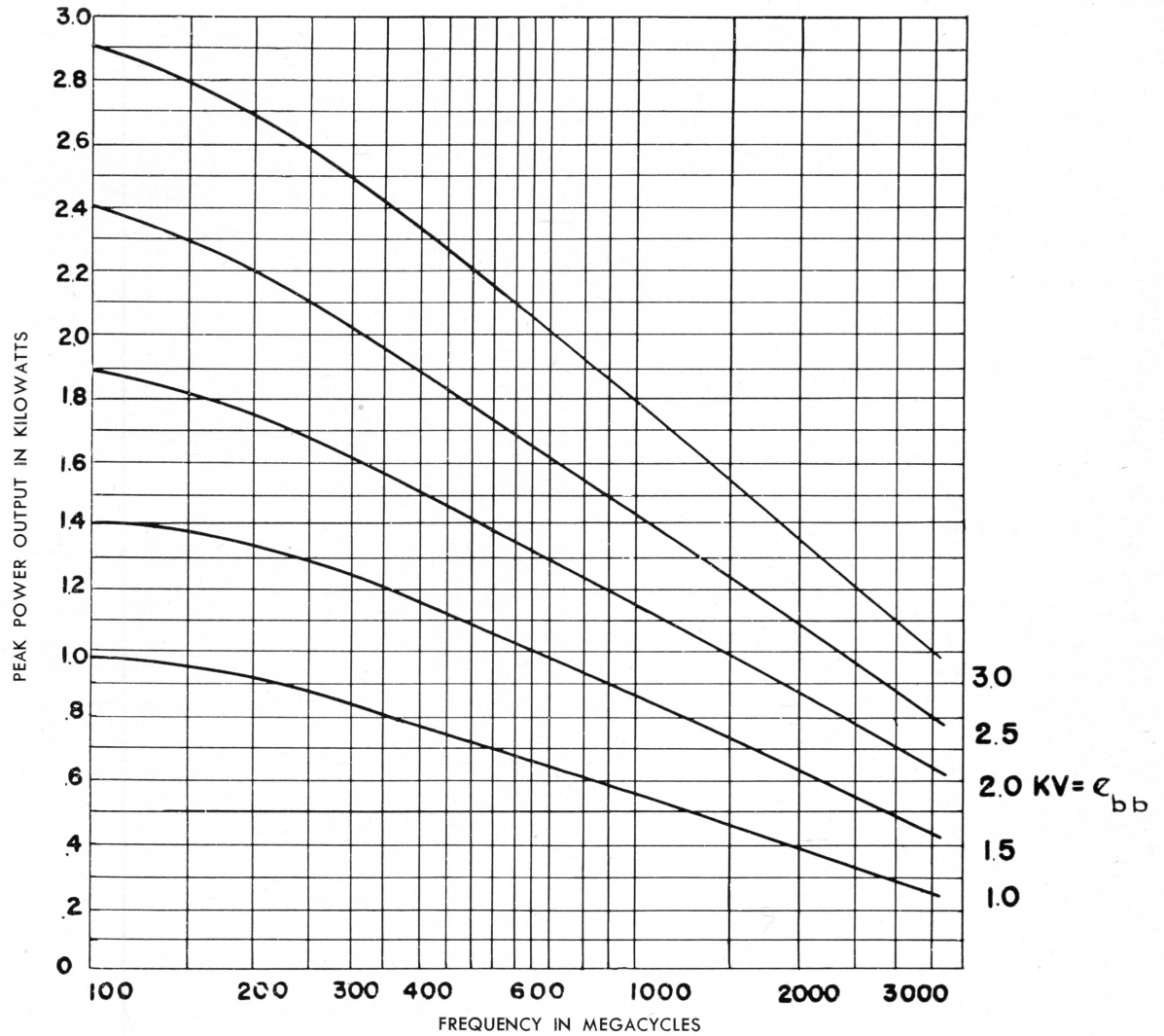
APPROXIMATE PLATE-PULSED OSCILLATOR PERFORMANCE

POWER OUTPUT VS. FREQUENCY

$I_b = 2.0$ AMPERES PEAK

PULSE RATE = 1000 PULSES PER SECOND

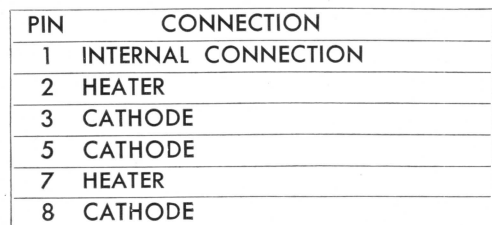
PULSE DURATION = 1 MICROSECOND



K-9033538

6-14-45

9-57



⊕ NOTE 3—ANODE CAP AND GRID RF CONNECTION TO BE CONCENTRIC WITH RESPECT TO THE CATHODE RF CONNECTION WITHIN $\frac{1}{64}$ INCH (RUN-OUT $\frac{1}{32}$ INCH, MAXIMUM).

GL-7D21

DESCRIPTION
AND RATING

ETX-219A

PAGE 1

3-48



TETRODE

The GL-7D21 is a four-electrode tube designed for use as a Class C radio-frequency amplifier. The anode is forced-air cooled and capable of dissipating

1200 watts. The cathode is a thoriated-tungsten filament. Maximum ratings apply up to 110 megacycles.

TECHNICAL INFORMATION

GENERAL

Electrical

	Nominal	Units
Filament voltage	6.3	volts
Filament current	30.0	amperes
Interelectrode capacitances		
Grid-plate	0.40	micromicrofarad
Input	39.0	micromicrofarads
Output	14.0	micromicrofarads
Grid-screen amplification factor	8	

GENERAL  ELECTRIC


Electronic
TUBE

Supersedes ETX-219 dated 5-47

TECHNICAL INFORMATION (CONT'D)

Mechanical

Mounting position	vertical, anode down
Type of cooling	forced air
Maximum incoming air temperature	50 centigrade
Required air flow on anode	
Plate dissipation	1200 watts
Air flow	55 cubic feet per minute
Pressure required	1½ inches water
Required air flow on filament terminals	
Air flow	5 cubic feet per minute
Maximum glass temperature	150 centigrade
Net weight, approximate	3¾ pounds

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Key-down conditions per tube without modulation*

Maximum Ratings, Absolute Values

D-c plate voltage	4000 volts
D-c screen voltage	750 volts
D-c grid voltage	-500 volts
D-c plate current	1.0 ampere
D-c grid current, approximate	135 milliamperes
Plate input	3000 watts
Screen input	60 watts
Plate dissipation	1200 watts
Radiator temperature†	180 centigrade

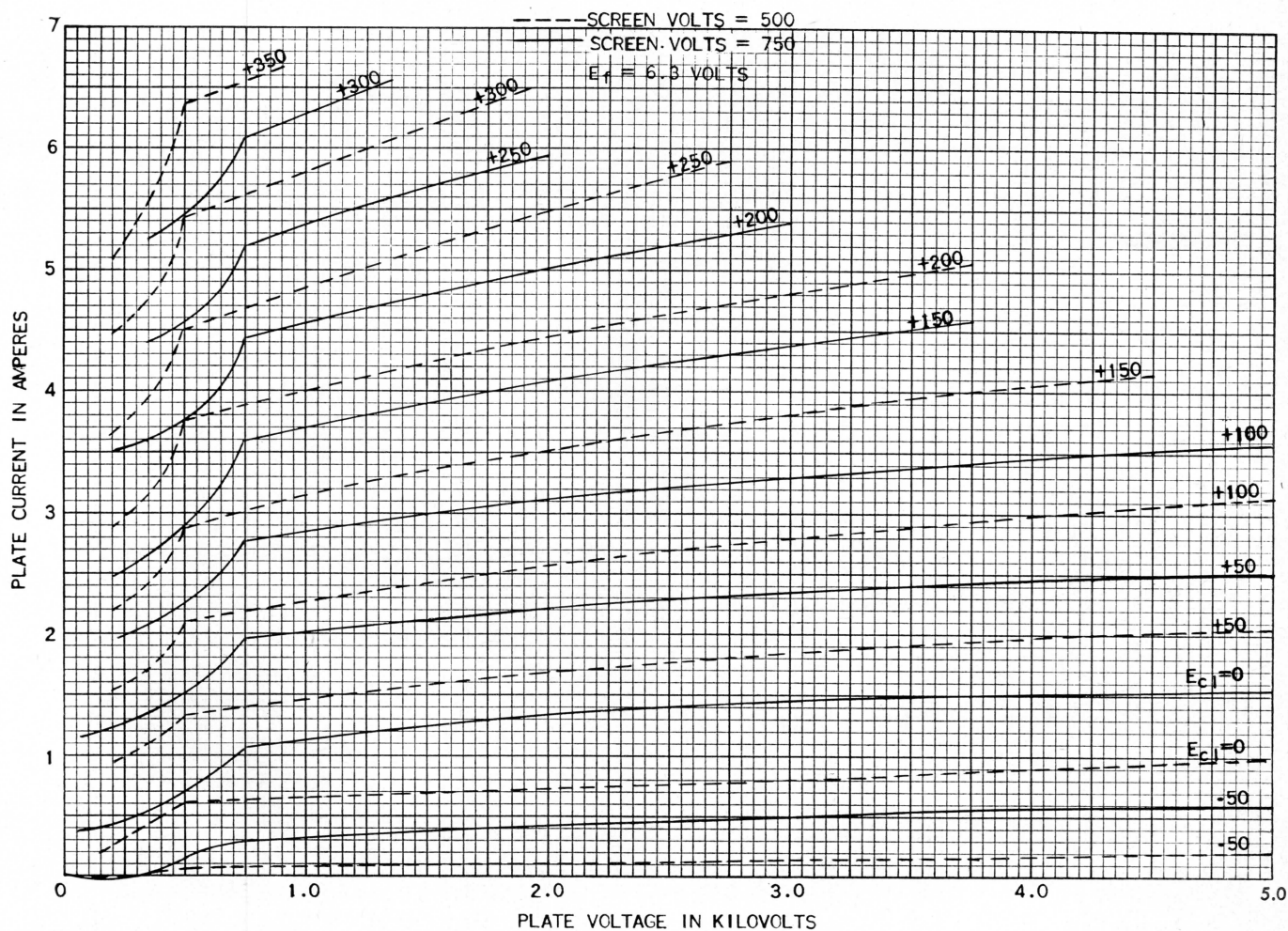
Typical Operation

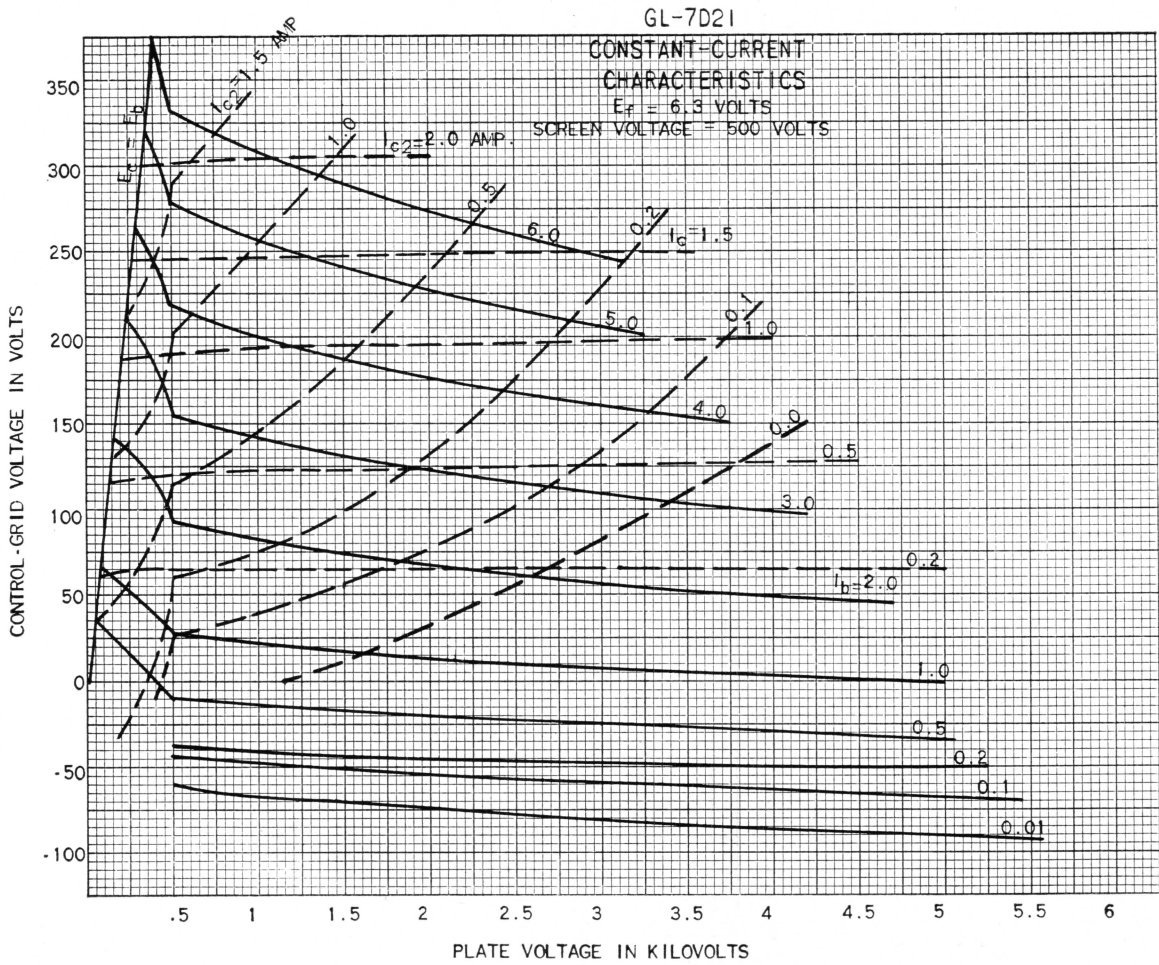
D-c plate voltage	3750 volts
D-c screen voltage	600 volts
D-c grid voltage	-102 volts
D-c plate current	0.67 ampere
D-c screen current	100 milliamperes
D-c grid current, approximate	51 milliamperes
Plate input	2510 watts
Screen input	60 watts
Peak r-f grid input voltage, approximate	300 volts
Driving power, approximate	60 watts
Plate power output, approximate	1575 watts

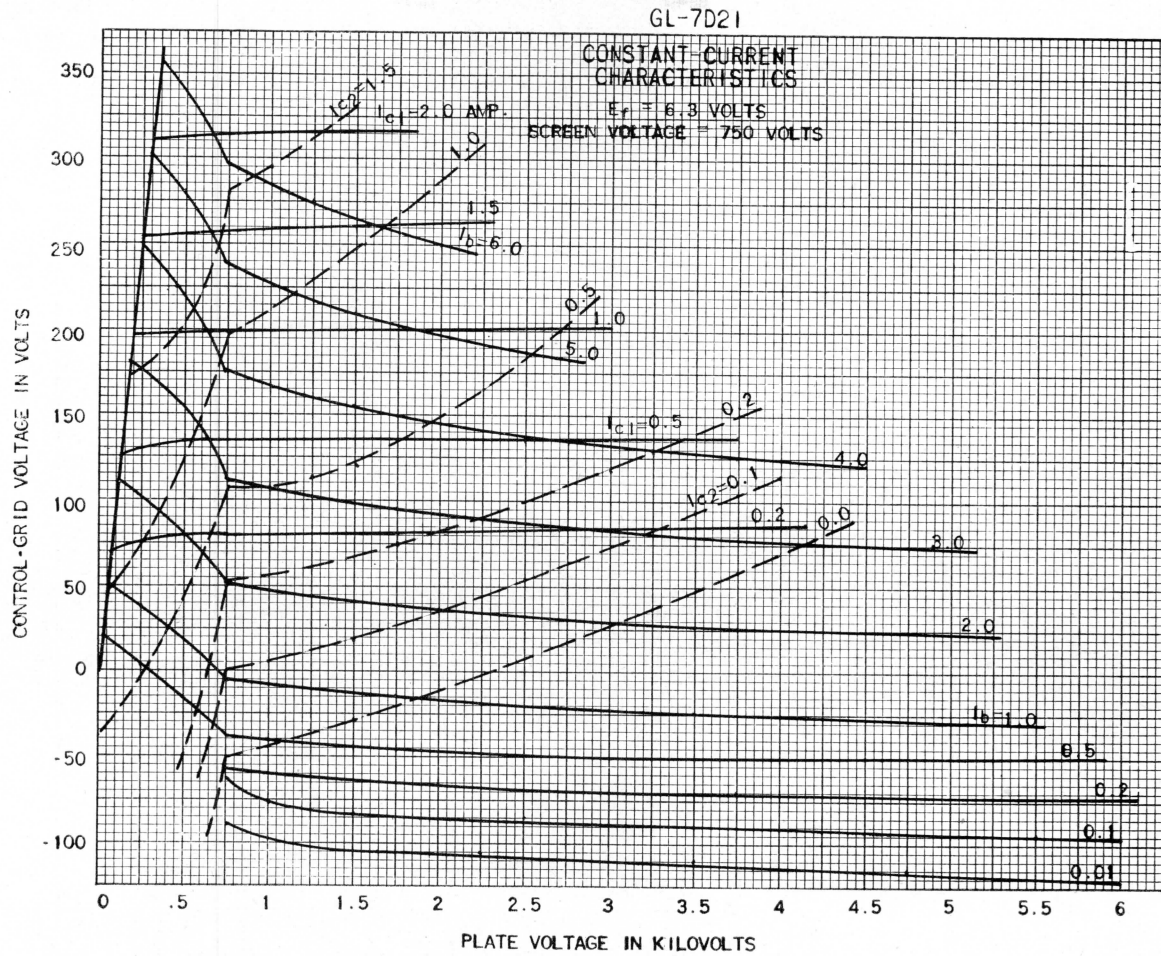
*Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

†These operational data are a result of actual test at 108 megacycles. Power output measured in load.

‡This temperature corresponds to the maximum ratings when the air flow is 55 cubic feet per minute, and the incoming air temperature does not exceed 50 C.

GL-7D21
PLATE CHARACTERISTICS





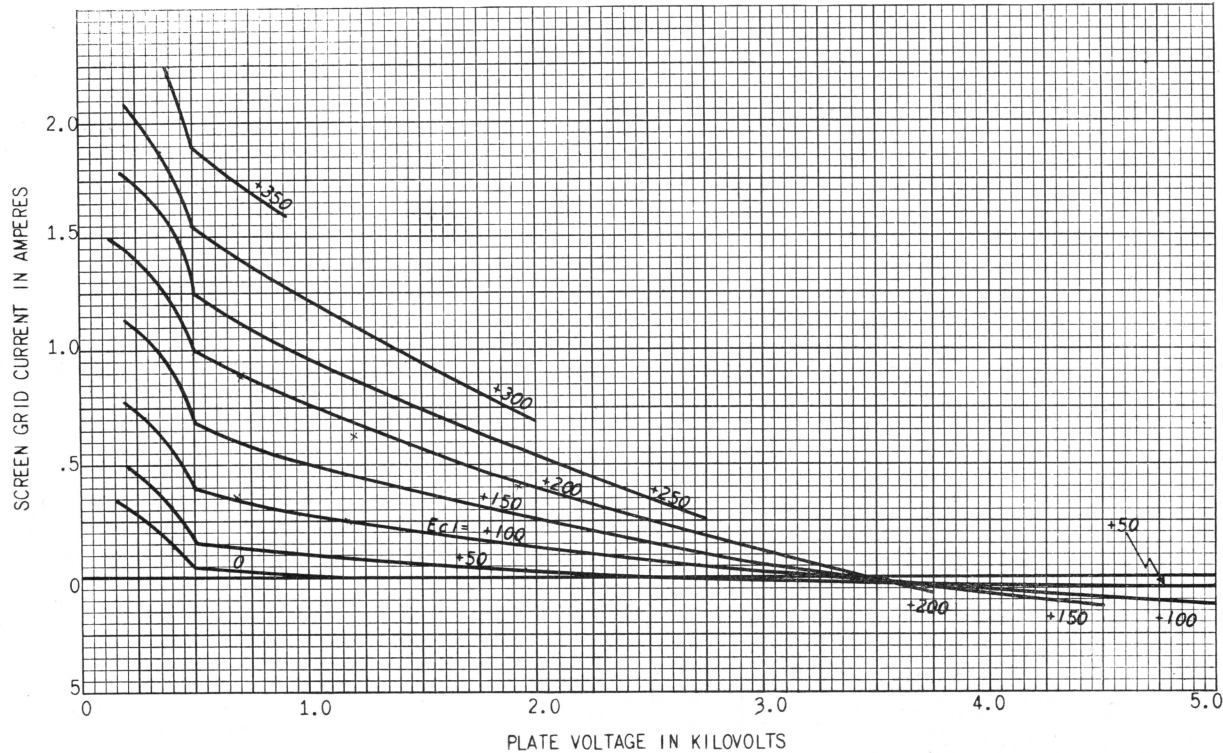
K-69087-72A89

7-1-47

GL-7D21

ETX-219A
PAGE 6
3-48

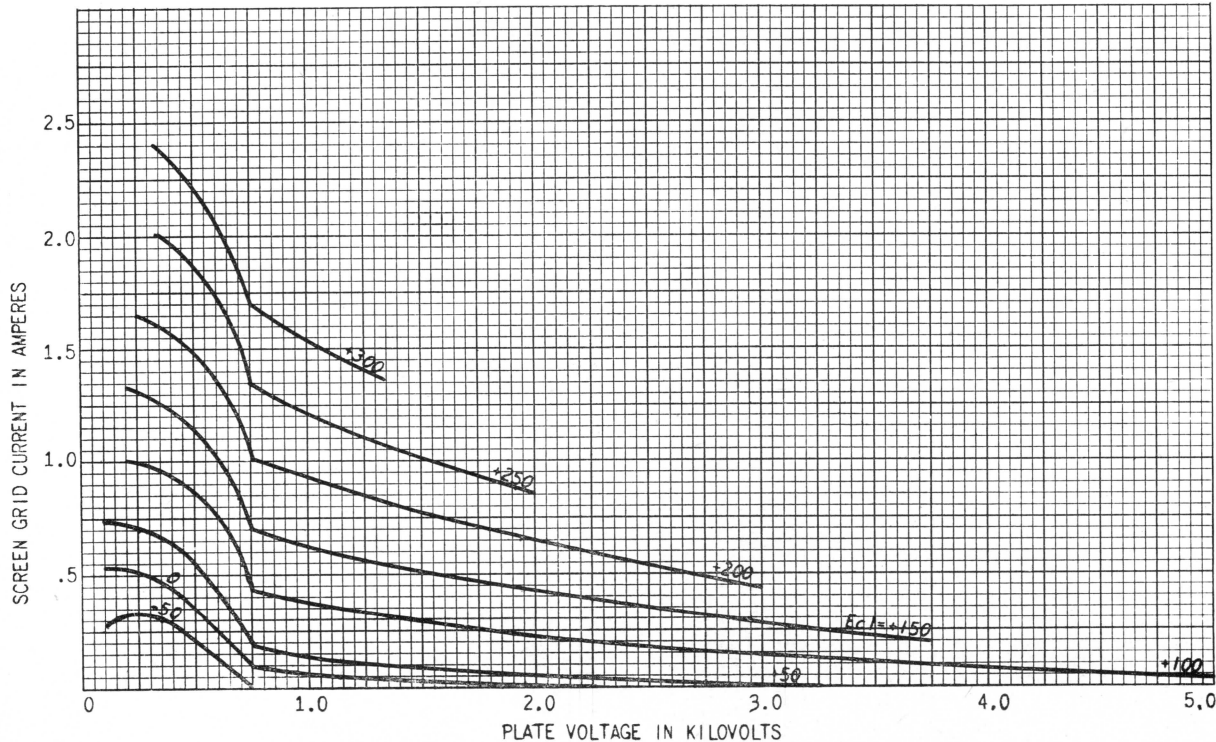
GL-7D21 SCREEN GRID CHARACTERISTICS
(SCREEN VOLTS = 500, $E_f = 6.3$ VOLTS)



K-69087-72A54

2-5-47

GL-7D21 SCREEN GRID CHARACTERISTICS
(SCREEN VOLTS = 750, $E_f = 6.3$ VOLTS)



K-69087-72A51

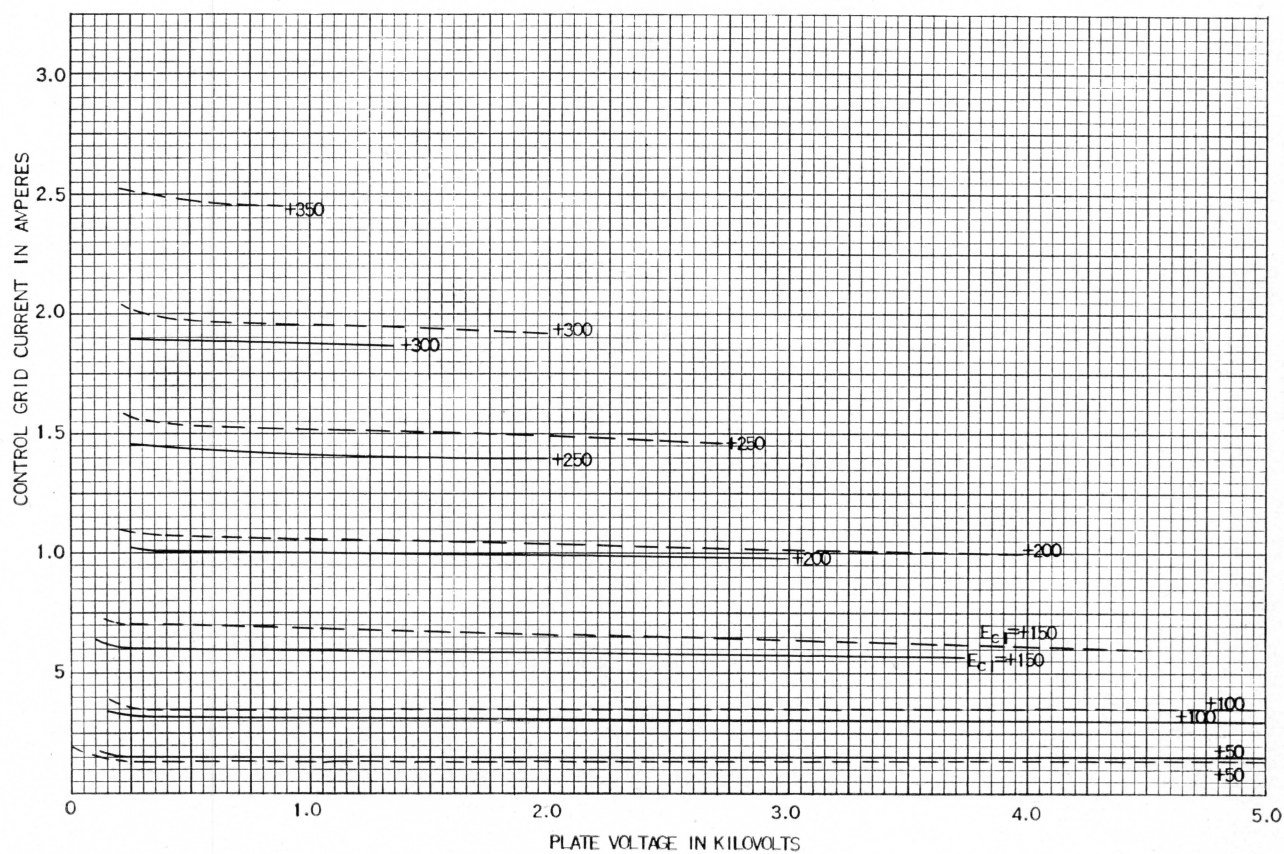
2-5-47

GL-7D21
CONTROL GRID CHARACTERISTICS

----- SCREEN VOLTS = 500

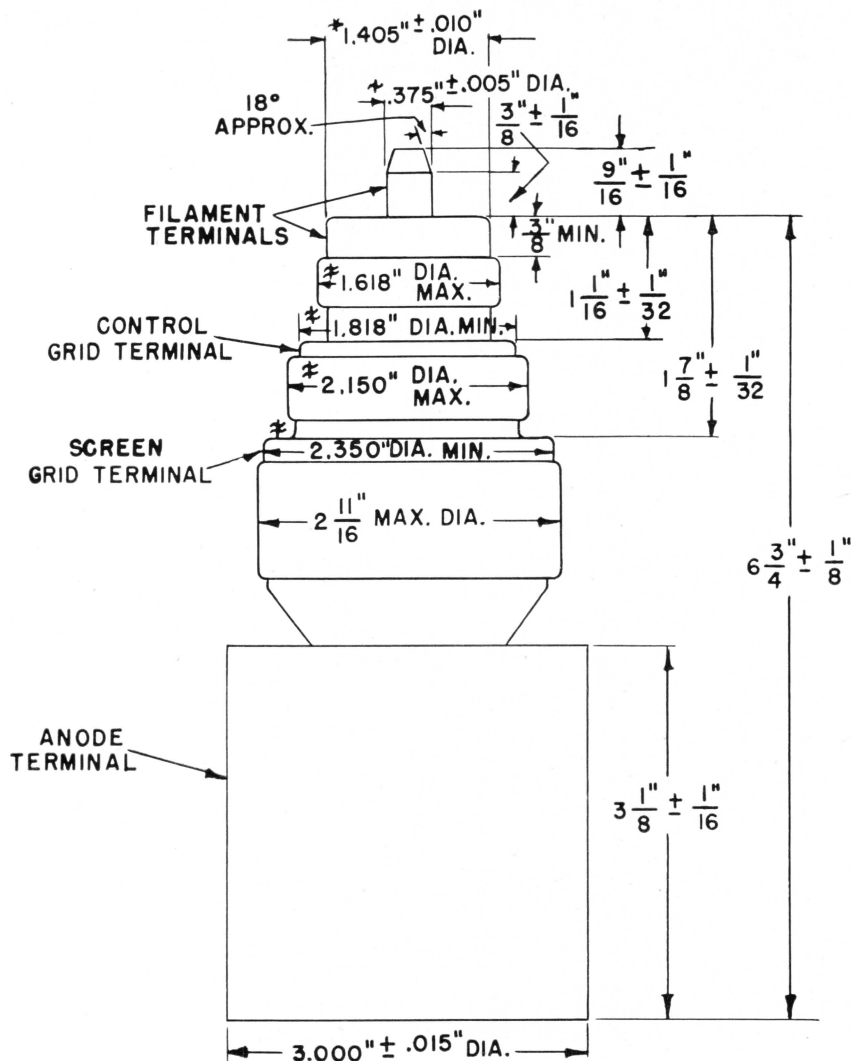
——— SCREEN VOLTS = 750

$E_i = 6.3$ VOLTS



K-69087-72A120

3-24-47



- NOTES: * MAX. ECCENTRICITY OF LARGER DIA. FILAMENT TERMINAL IS .050" WITH RESPECT TO THE AXIS OF RADIATOR.
 ♦ MAX. ECCENTRICITY OF SMALLER DIA. FILAMENT TERMINAL IS .020" WITH RESPECT TO A CENTERLINE ESTABLISHED BY THE CENTER OF THE BOTTOM OF RADIATOR AND CENTER OF LARGER DIA. FILAMENT TERMINAL.
 ✱ MAX. OR MIN. DIMENSIONS OF ANY POINT ON CIRCUMFERENCE OF PART, CIRCUMFERENCES CONCENTRIC WITH A CENTERLINE ESTABLISHED BY THE CENTER OF THE BOTTOM OF RADIATOR AND CENTER OF LARGER DIA. FILAMENT TERMINAL.

GL-7D21 OUTLINE

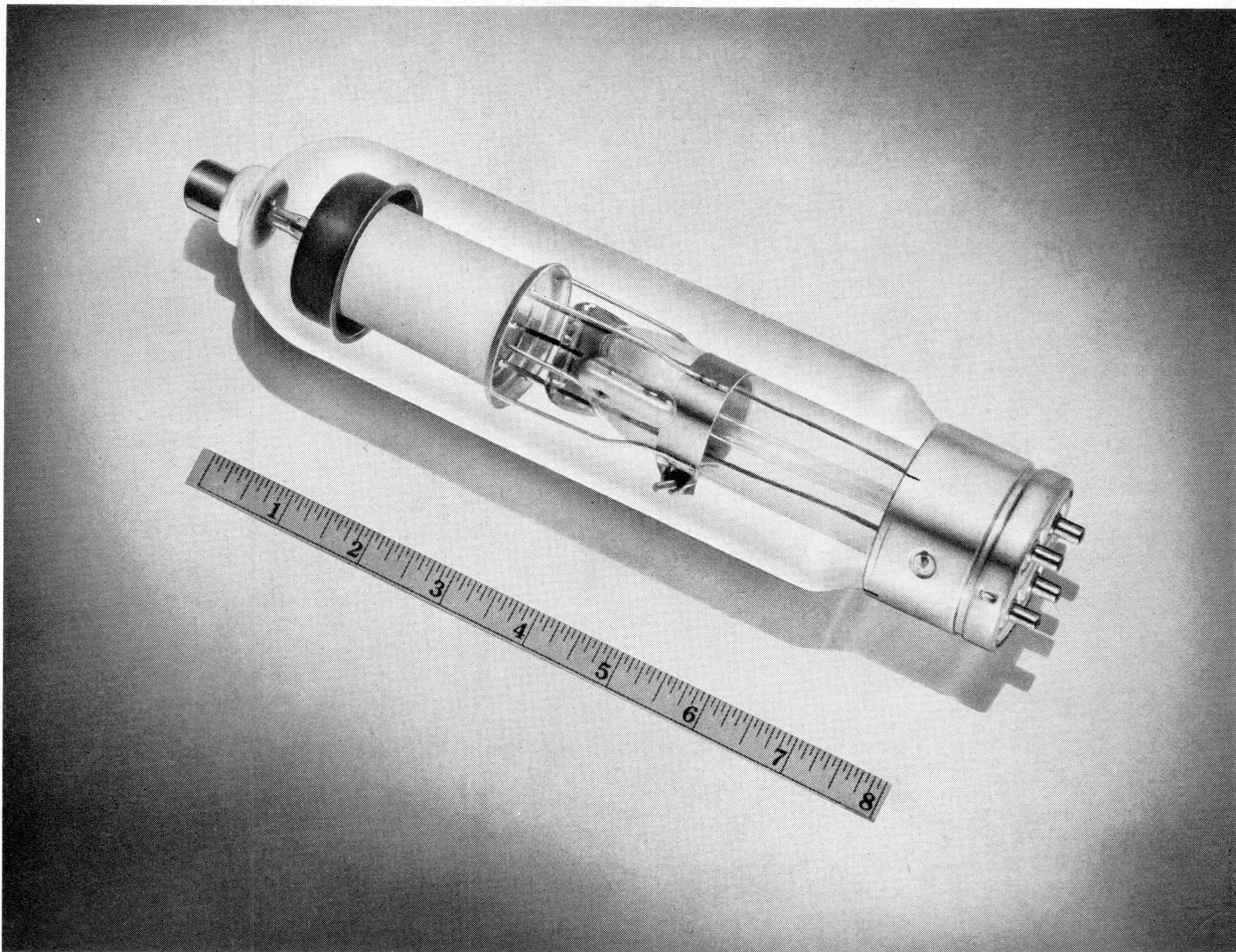
N-21206AZ

4-18-46

ELECTRONIC COMPONENTS DIVISION

GENERAL  **ELECTRIC**

Schenectady 5, N. Y.



PHANOTRON

HALF-WAVE

MERCURY-VAPOR

The GL-575-A is a half-wave, mercury-vapor inverse voltages, and to conduct at relatively low rectifier tube designed to withstand high peak applied voltages.

TECHNICAL INFORMATION

GENERAL

Electrical

☐ Cathode—Filamentary

	Minimum	Bogey	Maximum	
Filament Voltage.....	4.75	5.0	5.25	Volts

☐ Filament Current at 5.0 Volts.....	9.0	10.0	11.5	Amperes
---	-----	------	------	---------

Heating Time.....	30			Seconds
-------------------	----	------	------	---------

Anode Voltage Drop, typical.....		10		Volts
----------------------------------	------	----	------	-------

⊕Critical Anode Voltage.....			100	Volts
------------------------------	------	------	-----	-------

Mechanical

Type of Cooling—Convection

Equilibrium Condensed-Mercury Temperature Rise Above Ambient

At Full Load, approximate.....	20	C
--------------------------------	----	---

At No Load, approximate.....	12	C
------------------------------	----	---

Mounting Position—Vertical, Base Down

Net Weight, maximum.....	13	Ounces
--------------------------	----	--------

GENERAL  ELECTRIC

TECHNICAL INFORMATION (CONT'D)

MAXIMUM RATINGS, Absolute Values

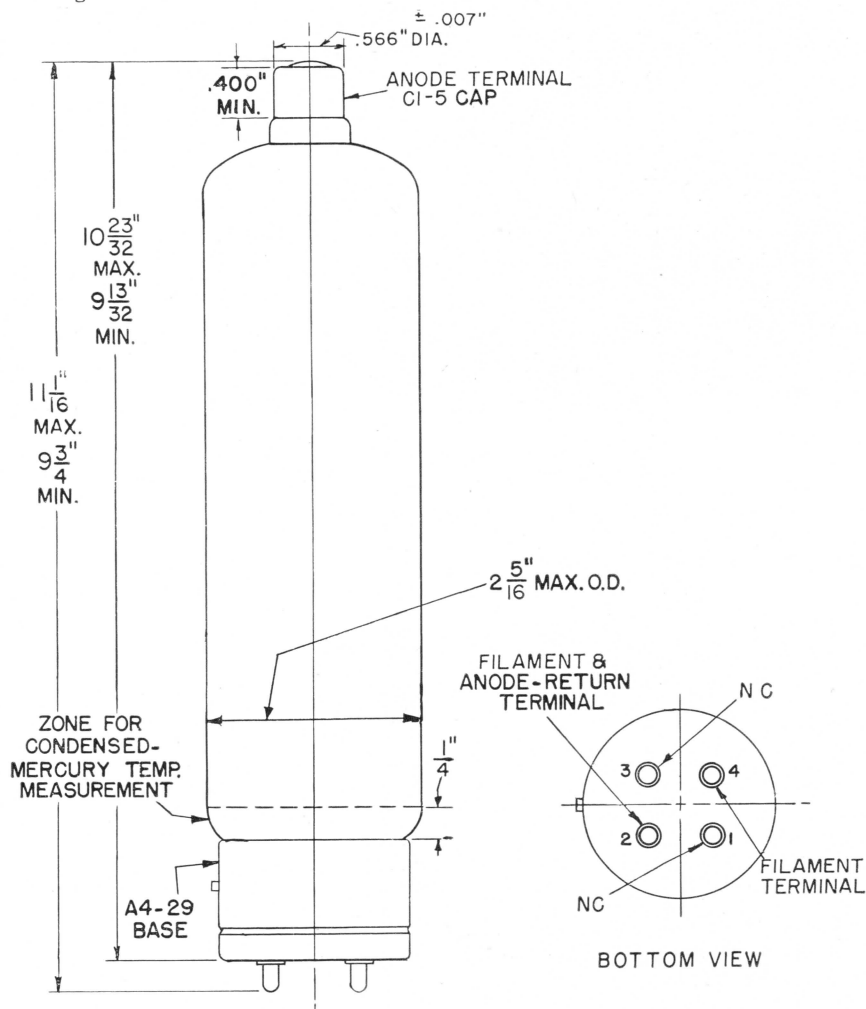
Maximum Peak Inverse Anode Voltage.....	10,000	15,000 Volts
Maximum Cathode Current		
□ Peak		
Quadrature Operation.....	10.0	10.0 Amperes
In Phase Operation.....	7.0	6.0 Amperes
□ Average		
Quadrature Operation.....	2.5	2.5 Amperes
In Phase Operation.....	1.75	1.5 Amperes
⊕ Fault.....	100	100 Amperes
⊕ Maximum Duration.....	0.1	0.1 Seconds
Maximum Averaging Time.....	20	20 Seconds
Frequency.....	150	150 Cycles per Second

Condensed-Mercury Temperature Limits*..... +20 to +60 +20 to +50 C

*Maximum temperature ratings for intermediate peak inverse voltages may be determined by linear interpolation. When this is done lower current rating applies.

□ Denotes an addition.

⊕ Denotes a change.



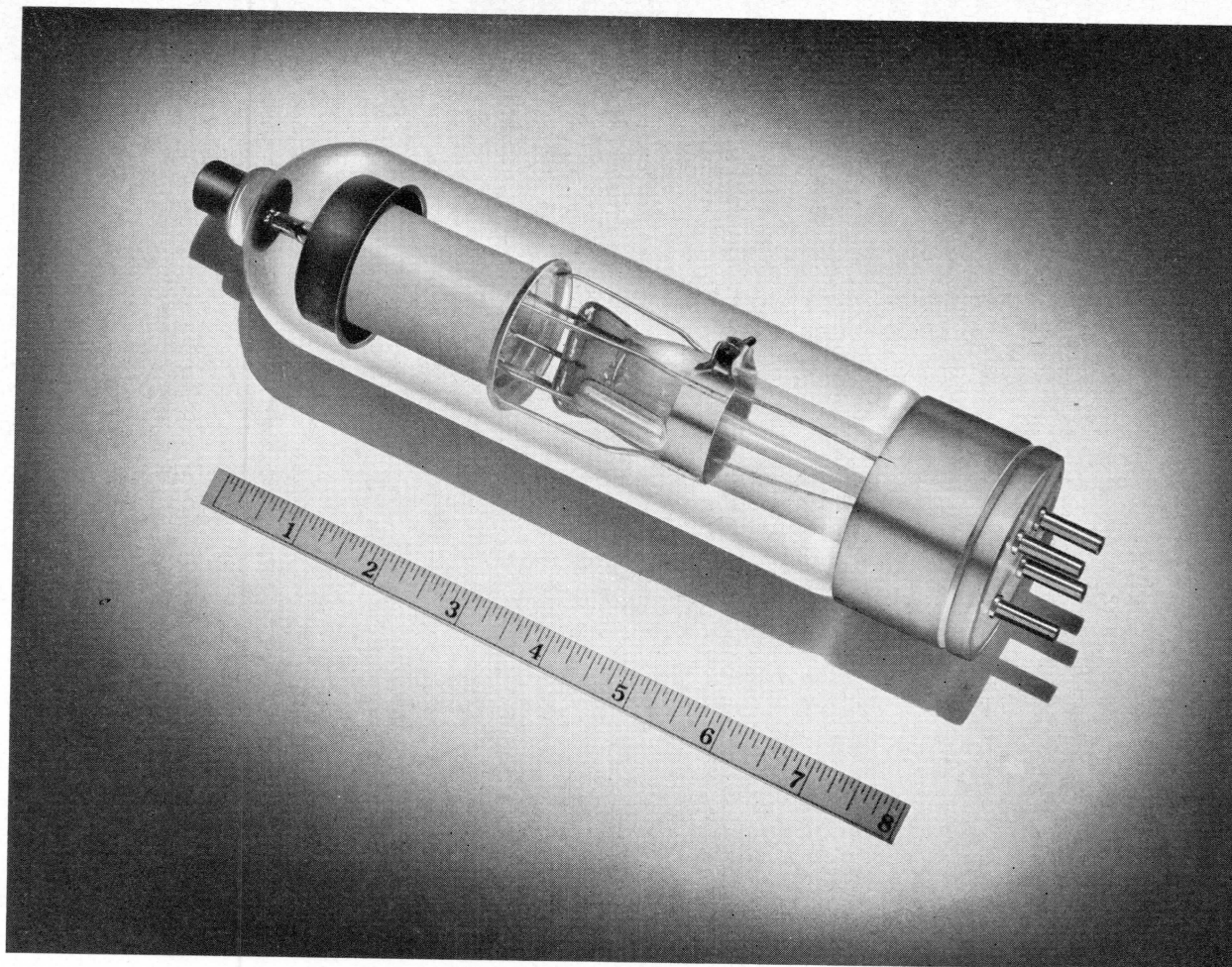
N-21500AZ—Outline revised.

12-30-57

ELECTRONIC COMPONENTS DIVISION

GENERAL  ELECTRIC

Schenectady 5, N. Y.



PHANOTRON

HALF-WAVE

MERCURY-VAPOR

The GL-673 is a half-wave, mercury-vapor rectifier tube designed to withstand high peak inverse

voltages, and to conduct at relatively low applied voltages.

TECHNICAL INFORMATION

GENERAL

Electrical

	Minimum	Bogey	Maximum
Cathode—Filamentary			
Filament Voltage.....	4.75	5.0	5.25 Volts
Filament Current, at 5.0 Volts.....	9.0	10.0	11.5 Amperes
Heating Time.....	30	—	— Seconds
Anode Voltage Drop, typical.....	—	10	— Volts
Critical Anode Voltage.....	—	—	100 Volts

Mechanical

Type of Cooling—Convection	
Equilibrium Condensed-Mercury Temperature Rise over Ambient	
At Full Load, approximate.....	20 C
At No Load, approximate.....	12 C
Base—Super-Jumbo 4-Pin Bayonet, A4-18.	
Cap—Medium Metal, C1-5.	
Mounting Position—Vertical, Base Down	
Net Weight, approximate.....	13 Ounces

GENERAL  ELECTRIC

TECHNICAL INFORMATION (CONT'D)

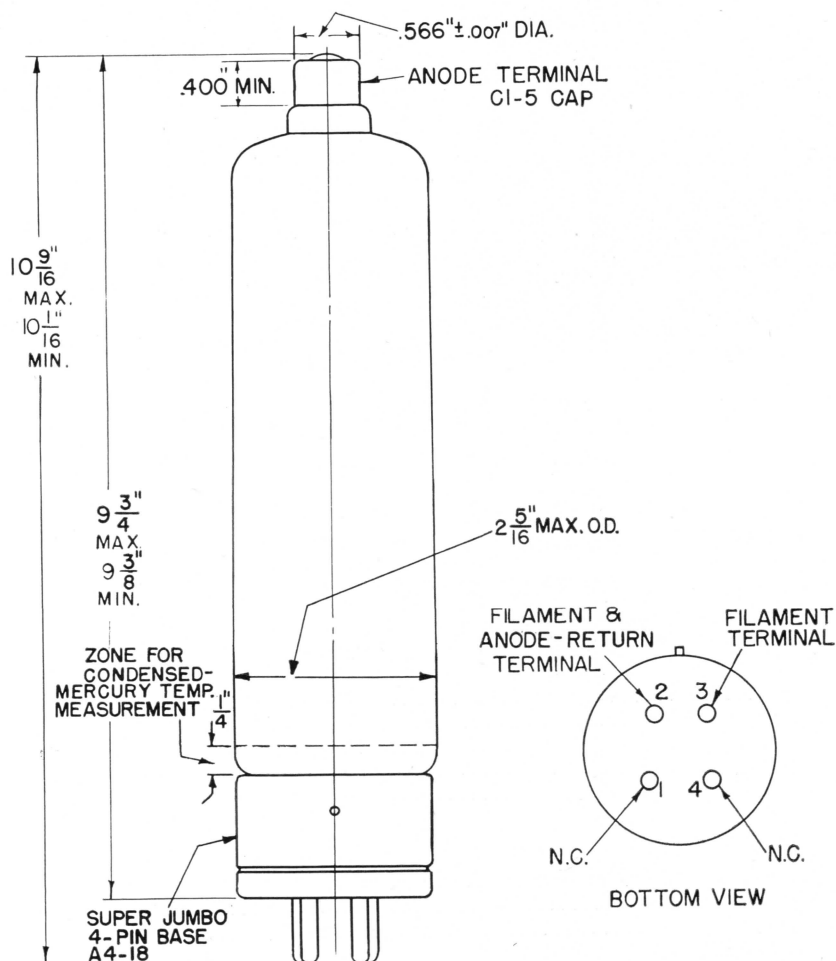
MAXIMUM RATINGS, Absolute Values

Maximum Peak Inverse Anode Voltage.....	10,000	15,000 Volts
Maximum Cathode Current		
□ Peak		
Quadrature Operation.....	10.0	10.0 Amperes
In Phase Operation.....	7.0	6.0 Amperes
□ Average		
Quadrature Operation.....	2.5	2.5 Amperes
In Phase Operation.....	1.75	1.5 Amperes
⊕ Fault.....	100	100 Amperes
Maximum Duration.....	0.1	0.1 Seconds
Maximum Averaging Time.....	20	20 Seconds
Condensed-Mercury Temperature Limits*.....	+20 to +60	+20 to +50 C
Maximum Frequency.....	150	150 Cycles per Second

*Maximum temperature ratings for intermediate peak inverse voltages may be determined by linear interpolation. When this is done lower current rating applies.

□ Denotes an addition.

⊕ Denotes a change.



N-21501AZ—Outline revised

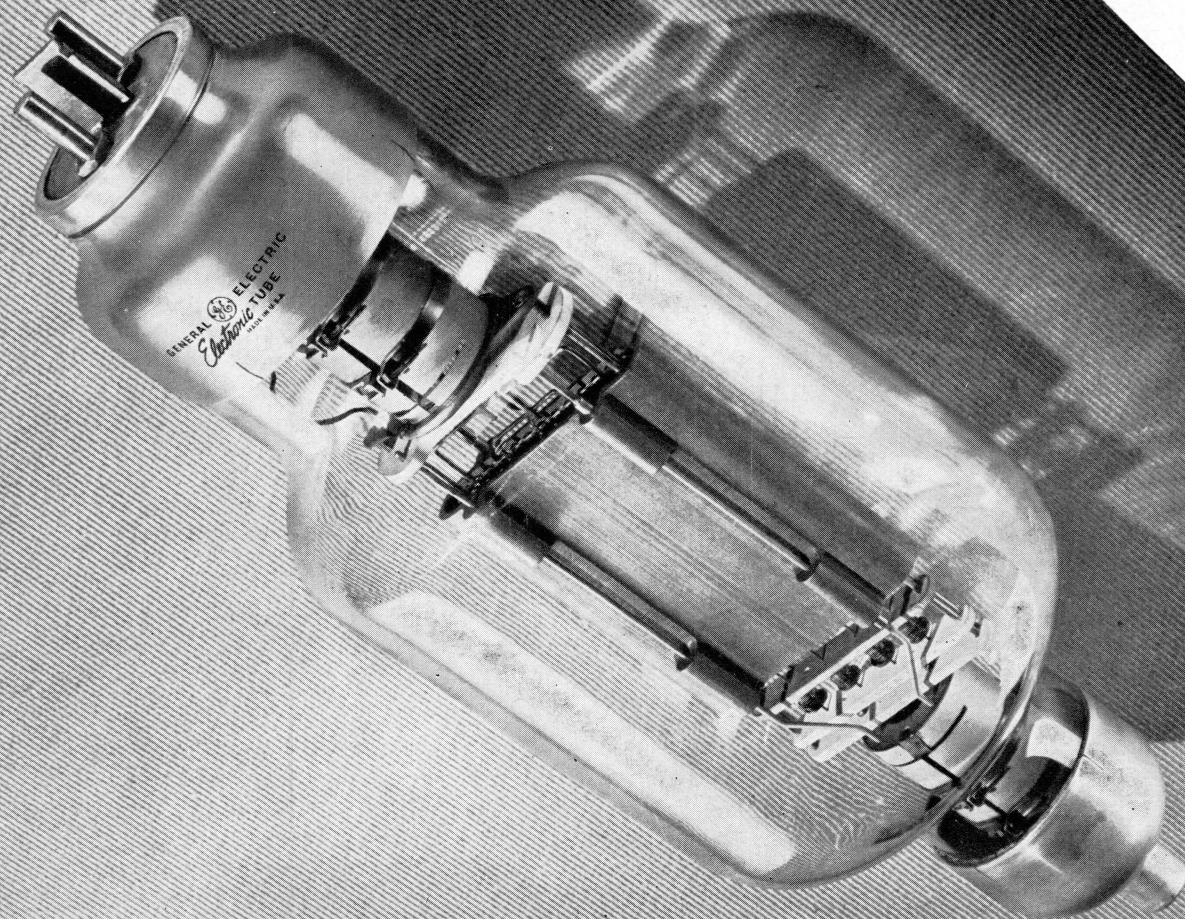
12-30-57

ELECTRONIC COMPONENTS DIVISION

GENERAL  ELECTRIC

Schenectady 5, N. Y.

PRINTED
IN
U.S.A.



TRIODE

The GL-851 is a three-electrode, general purpose oscillator, or Class B modulator. The plate of this tube designed for use as a radio-frequency amplifier, tube is capable of dissipating 500 to 750 watts.

TECHNICAL INFORMATION

GENERAL

Number of electrodes.....3

Electrical

Cathode—Filamentary

Filament voltage.....11 volts

Filament current.....15.5 amperes

Average characteristics

Amplification factor, $I_f = 300$ ma.....20.5

Grid-plate transconductance.....15000 micromhos

Direct interelectrode capacitances

Grid plate.....47 micromicrofarads

Input.....25.5 micromicrofarads

Output.....4.5 micromicrofarads

Frequency for maximum ratings.....3 megacycles

Mechanical

Type of cooling.....convection

Maximum ambient temperature.....60 centigrade

Net weight, approximate.....3 pounds

Mounting position.....vertical, filament base (large) up or
horizontal, filament in vertical plane (on edge)

Shipping weight, approximate.....9 pounds


Electronic
TUBE

GENERAL  ELECTRIC

TECHNICAL INFORMATION (CONT'D)

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

	Typical Operation			Maximum Ratings	
CLASS A AUDIO-FREQUENCY AMPLIFIER AND MODULATOR					
D-c plate voltage.....	1500	2000	2500	2500	volts
Plate dissipation.....				600	watts
D-c grid voltage.....	-49	-65	-92		volts
Peak grid swing, approximate.....	44	60	87		volts
D-c plate current.....	0.175	0.270	0.240		ampere
Plate resistance.....	1800	1500	1600		ohms
Load resistance.....	3700	3100	5000		ohms
Plate power output, 5 per cent second harmonic.....	46	100	160		watts

CLASS B AUDIO-FREQUENCY POWER AMPLIFIER (TWO TUBES)

D-c plate voltage.....	2000	2500	3000	3000	volts
Maximum signal plate current, per tube*.....				1	ampere
D-c maximum signal plate input, per tube*.....				2250	watts
Plate dissipation, per tube*.....				750	watts
D-c grid voltage.....	-85	-111	-135		volts
Peak a-f grid input voltage.....	250	245	245		volts
Zero signal plate current.....	0.12	0.12	0.11		ampere
Maximum signal plate current.....	1.7	1.4	1.2		amperes
Maximum signal plate input*.....	3400	3500	3600		watts
Maximum signal driving power, approximate.....	20	12	6		watts
Effective load resistance, plate-to-plate.....	2600	4000	5600		ohms
Maximum signal plate power output.....	2200	2300	2400		watts

CLASS B RADIO-FREQUENCY POWER AMPLIFIER

Carrier conditions per tube for use with a maximum modulation factor of 1.0

D-c plate voltage.....	1500	2000	2500	2500	volts
D-c grid voltage.....	-60	-85	-110		volts
D-c plate current.....	0.62	0.475	0.39	0.750	ampere
Plate input.....				1100	watts
Plate dissipation.....				750	watts
Peak r-f grid input voltage.....	300	280	270		volts
Driving power, approximate†.....	40	25	20		watts
Plate power output.....	275	300	325		watts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—PLATE-MODULATED

Carrier conditions per tube for use with a max modulation factor of 1.0

D-c plate voltage.....	1500	2000	2000	volts
D-c grid voltage.....	-250	-300	-500	volts
D-c plate current.....	0.9	0.85	1	ampere
D-c grid current, approximate.....	0.15	0.125	0.200	ampere
Plate input.....			1800	watts
Plate dissipation.....			500	watts
Peak r-f grid input voltage, approximate.....	475	525		volts
Driving power, approximate.....	75	65		volts
Plate power output.....	900	1250		watts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Key-down conditions per tube without modulation‡

D-c plate voltage.....	1500	2000	2500	2500	volts
D-c grid voltage.....	-150	-200	-250	-500	volts
D-c plate current.....	0.9	0.9	0.9	1	ampere
D-c grid current, approximate.....	0.15	0.12	0.1	0.200	ampere
Plate input.....				2500	watts
Plate dissipation.....				750	watts
Peak r-f grid input voltage, approximate.....	375	425	450		volts
Driving power, approximate.....	55	50	45		watts
Plate power output.....	900	1250	1700		watts

* Averaged over any audio-frequency cycle.

† At crest of audio-frequency cycle.

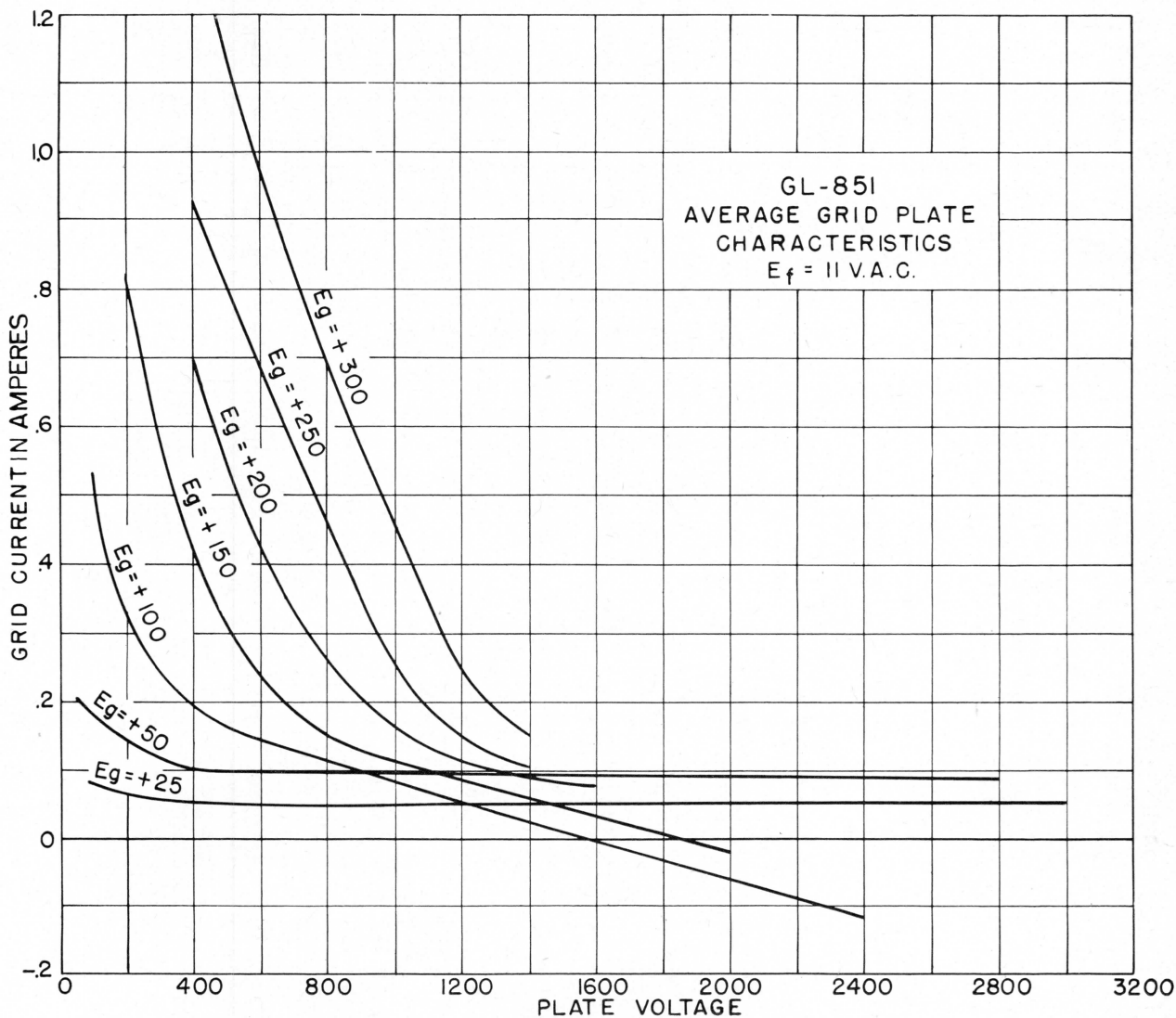
‡ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

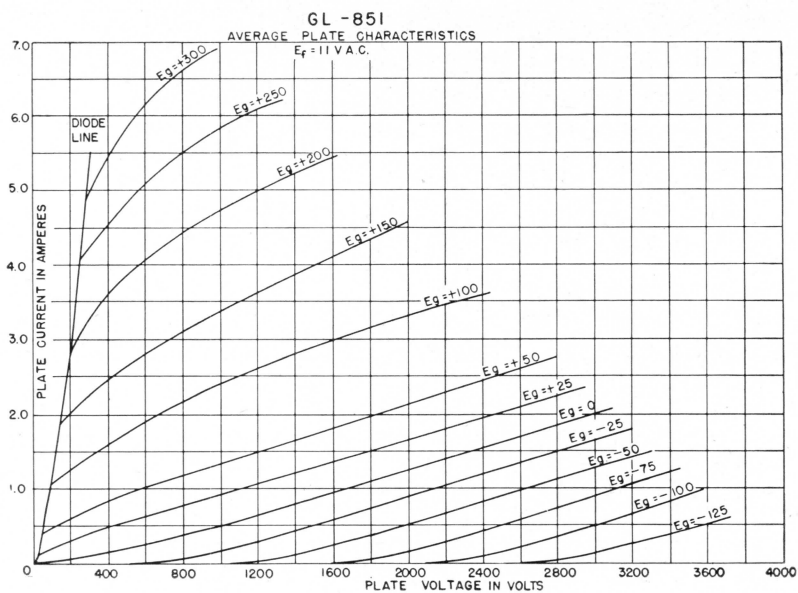
APPLICATION NOTES

GL-851 can be operated at maximum ratings in all classes of service at frequencies as high as 3 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under TECHNICAL INFORMATION.) The

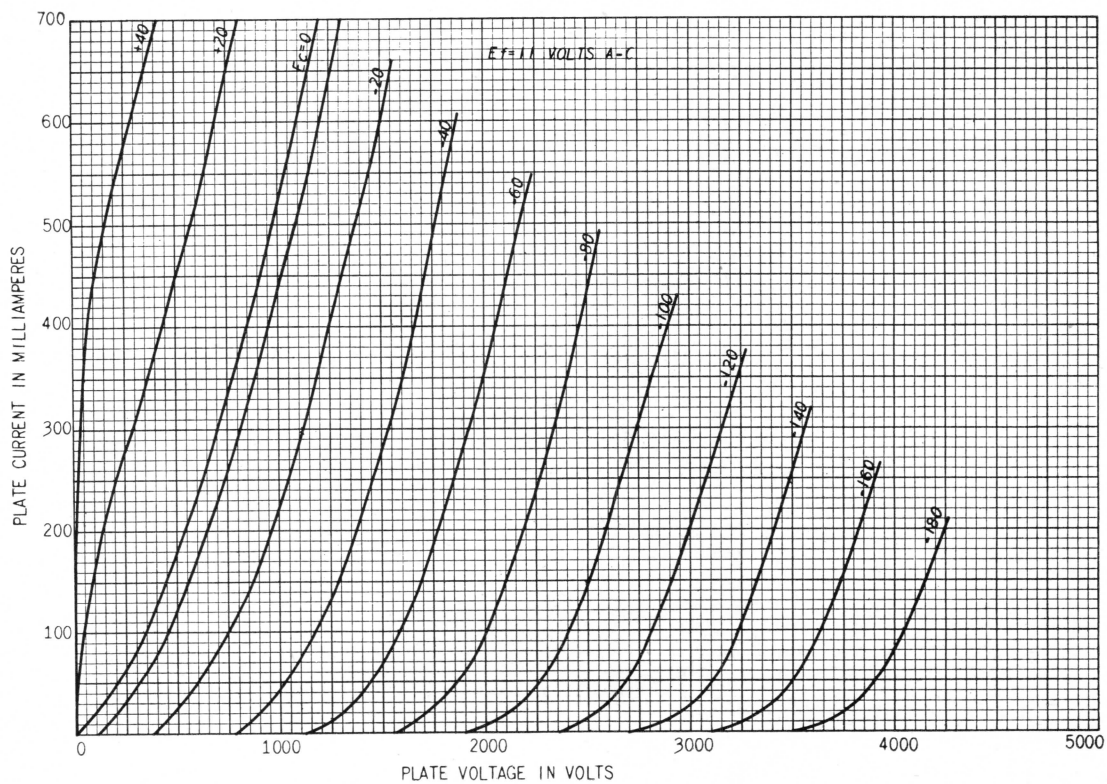
tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 15 mc for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

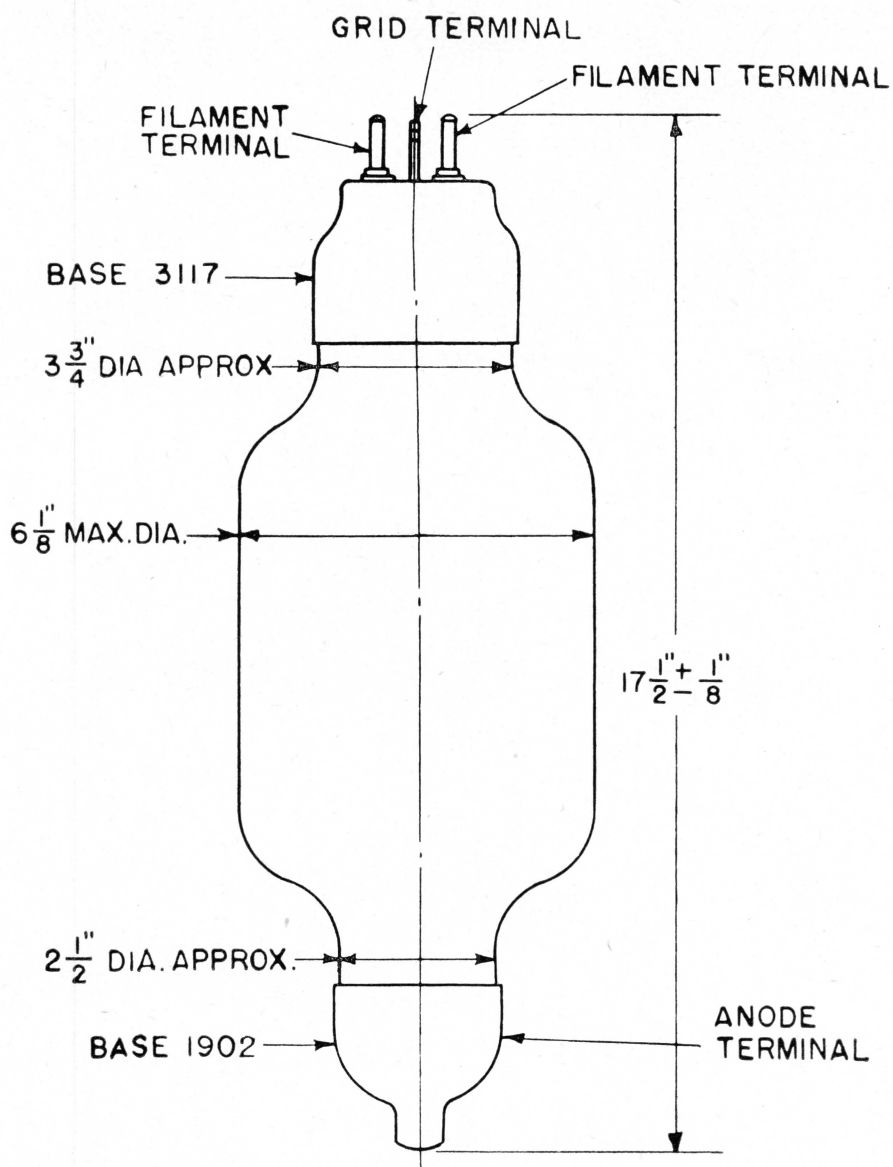
Frequency	3	7	15 megacycles
Maximum permissible percentage of maximum rated plate voltage and plate input:			
Class B, telephony	100	88	76 per cent
Class C, telephony, plate-modulated	100	75	50 per cent
Class C, telegraphy, plate-modulated	100	75	50 per cent





GL-851
AVERAGE PLATE CHARACTERISTICS



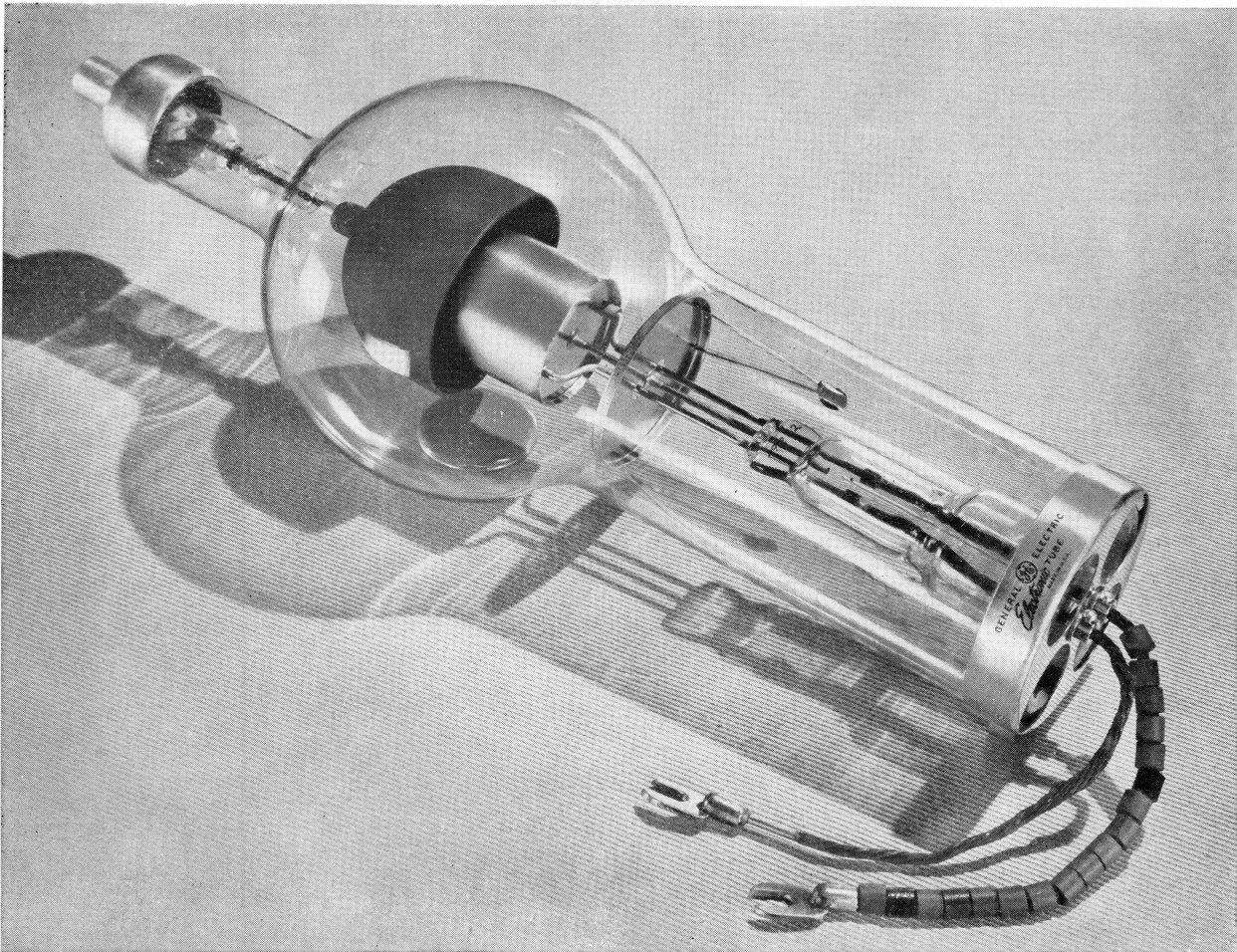


GL-851 OUTLINE

K-2636625

9-23-44

ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
Schenectady 5, N. Y.



PHANOTRON

The GL-857-B is a half-wave, mercury-vapor rectifier tube for use in the high voltage field. The low voltage drop characteristic inherent in mercury-vapor tubes, together with other features of design and construction assure maximum efficiency of operation in many different rectifier applications.

TECHNICAL INFORMATION

GENERAL

Electrical	Minimum	Bogey	Maximum
☐ Filament Voltage.....	4.75	5	5.25 Volts
☐ Filament Current at 5 Volts.....	—	30	33 Amperes
Cathode Heating Time.....	60	—	— Seconds
Anode Voltage Drop.....	—	15	— Volts
☐ Critical Anode Voltage.....	—	—	100 Volts
Mechanical			
Type of Cooling—Convection or Forced Air			
☐ Equilibrium Condensed-Mercury Temperature Rise above Ambient			
At Full Load, approximate.....			15 C
At No Load, approximate.....			11.5 C
Mounting Position—Vertical, Base Down			
⊕ Net Weight, maximum.....			3.5 Pounds

TECHNICAL INFORMATION (CONT'D)

MAXIMUM RATINGS, Absolute Values

	Convection	Forced Air
Maximum Peak Inverse Anode Voltage.....	10,000	22,000 Volts
⊕ Condensed-Mercury Temperature Limits.....	+25 to +60	+30 to +40 C
Maximum Cathode Current		
Peak.....	40	40 Amperes
Average.....	10	10 Amperes
Maximum Averaging Time.....	30	30 Seconds
Fault.....	400	400 Amperes
Maximum Duration.....	0.2	0.2 Seconds
Maximum Frequency.....	150	150 Cycles per Second

□ Denotes an addition.

⊕ Denotes a change.

□ X-RAY WARNING NOTICE

If the GL-857-B is operated at anode voltages in excess of 16 kilovolts, x-ray radiation shielding may be necessary to protect the user against possible danger of personal injury from prolonged exposure at close range. For further information consult the following references or other standard texts on the subject:

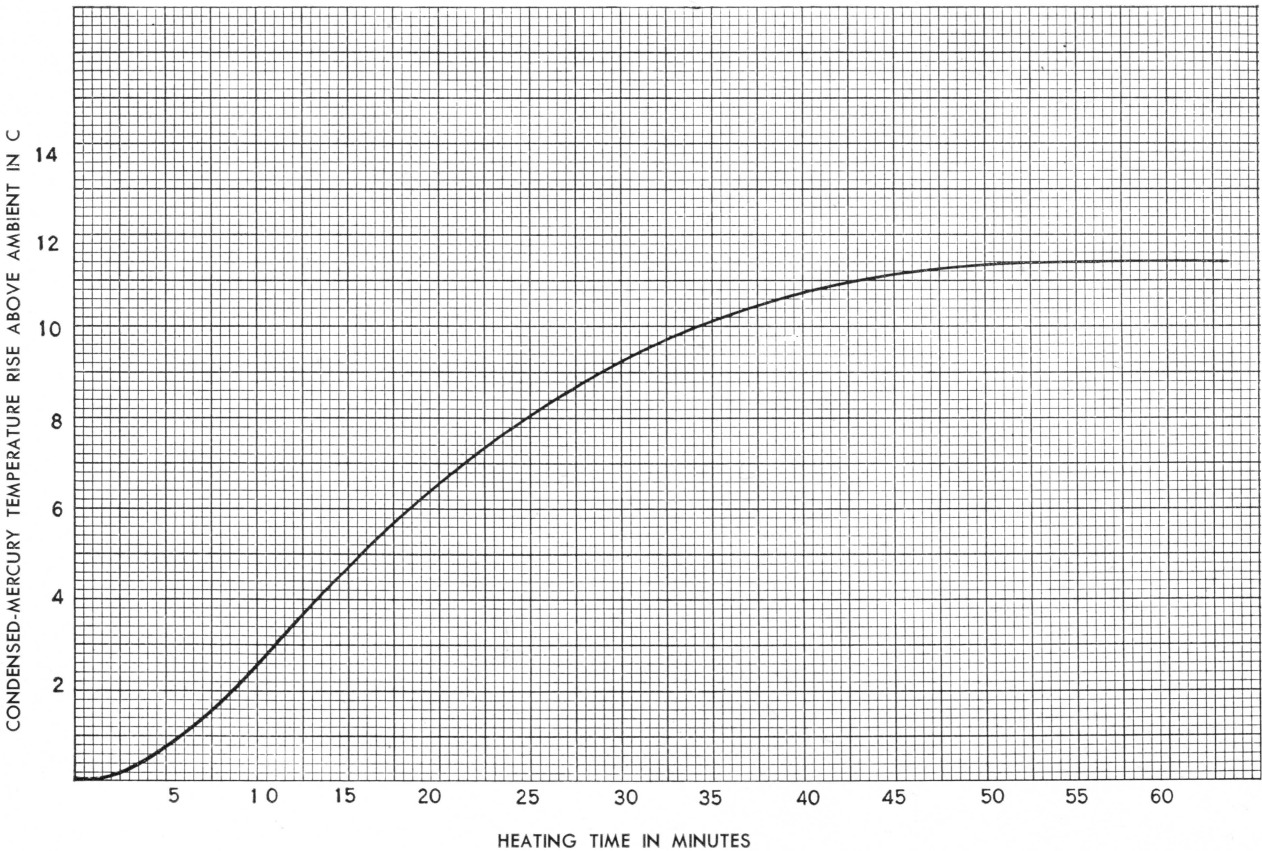
(a) *X-Ray Protection Design*, Handbook No. 50. National Bureau of Standards, Washington, D. C.

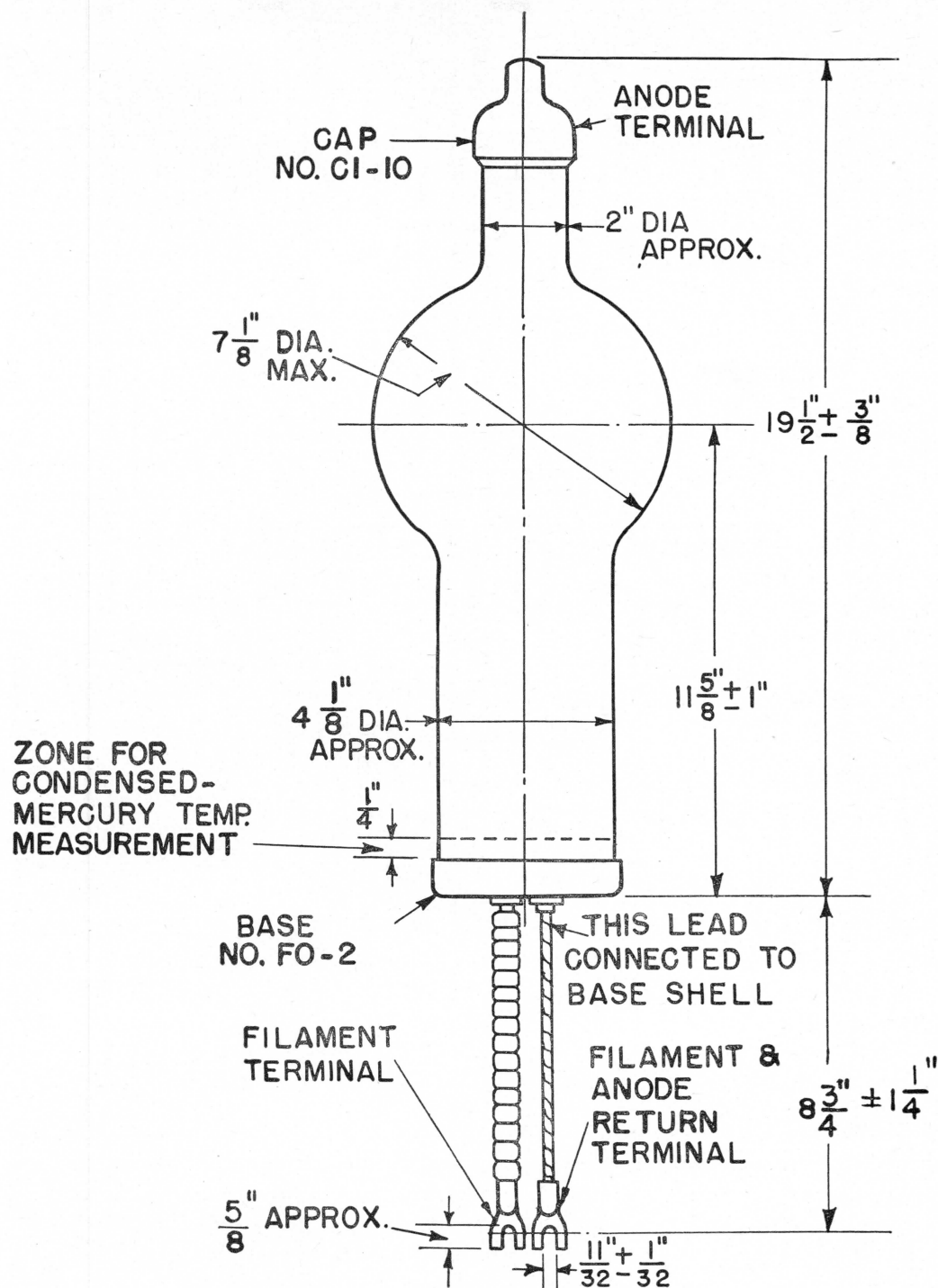
(b) *X-Ray Protection*, Handbook No. 60. National Bureau of Standards, Washington, D. C.

The above references are available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

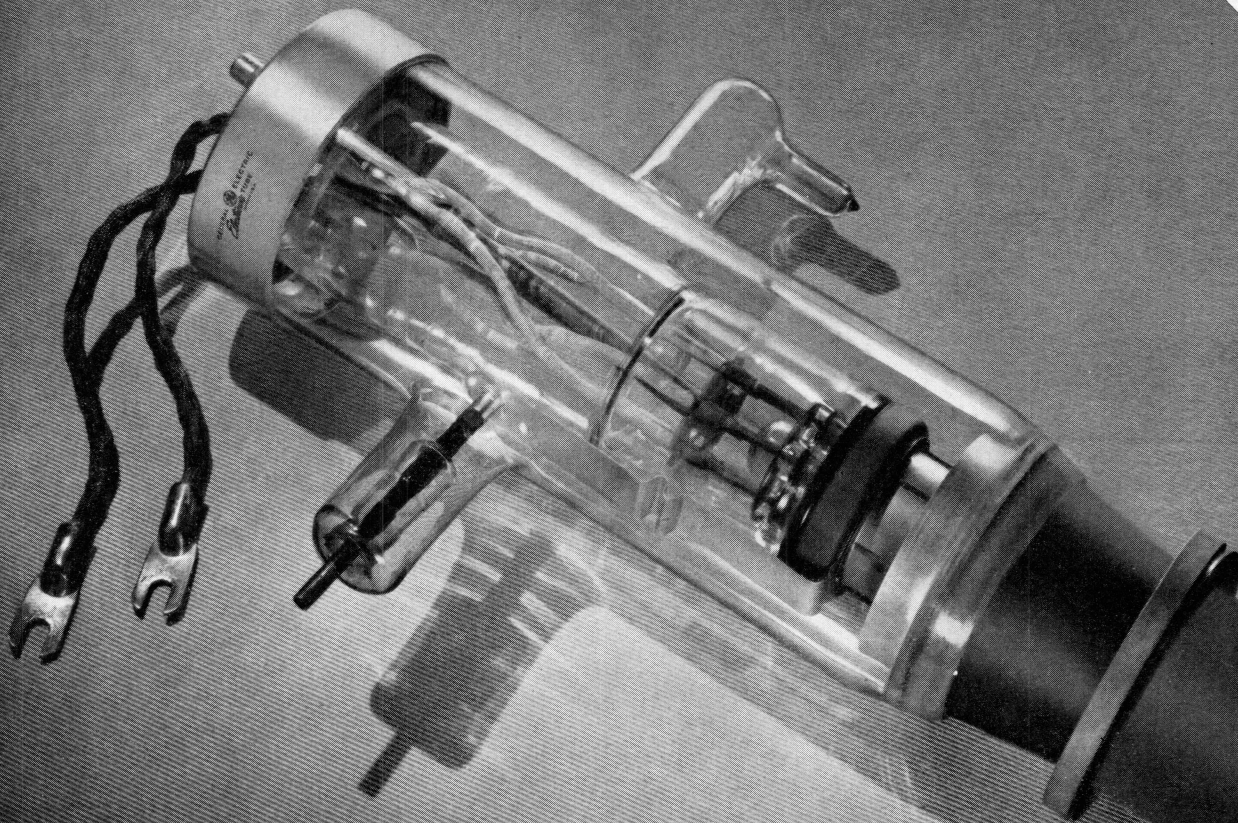
RATE OF RISE OF
CONDENSED-MERCURY TEMPERATURE

$E_f = 4.75$ VOLTS





ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
Schenectady 5, N. Y.



TRIODE

The GL-862-A is a three-electrode power transmitting tube designed for use as a radio-frequency amplifier, oscillator, or Class B modulator. The plate is water-cooled and is capable of dissipating

50 to 100 kilowatts, depending upon the class of service in which the tube is used. The GL-862-A may be used at maximum ratings at frequencies up to 1.6 megacycles.

TECHNICAL INFORMATION

GENERAL

Number of electrodes.....3

Electrical

Cathode—Filamentary

Filament voltage.....33 volts

Filament current.....207 amperes

Average characteristics

Amplification factor.....45

Grid-plate transconductance.....17200 micromhos

Direct interelectrode capacitances, approximate

Grid-plate.....69.5 micromicrofarads

Input.....53 micromicrofarads

Output.....4.5 micromicrofarads

Frequency for maximum ratings.....1.6 megacycles

GENERAL  ELECTRIC


Electronic
TUBE

TECHNICAL INFORMATION (CONT'D)

Mechanical

Base.....	6628
Gasket.....	Cat. No. 5182028P1
Type of cooling.....	water and forced air
Water flow.....	15-25 gal per min
Maximum outlet temperature.....	70 centigrade
Air flow.....	
To bulb.....	15 cu ft per min
To stem.....	3 cu ft per min
Net weight, approximate.....	30 pounds
Shipping weight, approximate.....	175 pounds
Mounting position.....	vertical, anode down

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B AUDIO-FREQUENCY AMPLIFIER (TWO TUBES)

	Typical Operation	Maximum Ratings
D-c plate voltage.....	12000	15000 volts
Maximum signal plate current, per tube*.....		7.5 amperes
D-c maximum signal plate input, per tube*.....		100 kilowatts
Plate dissipation*, per tube.....		50 kilowatts
D-c grid voltage.....	0	volts
Peak, a-f grid input voltage.....	2000	volts
Zero signal plate current.....	3	amperes
Maximum signal plate current.....	13	amperes
Maximum signal plate input*.....	156	kilowatts
Maximum signal driving power, approximate.....	450	watts
Effective load, plate-to-plate.....	1800	ohms
Maximum signal plate power output.....	90	kilowatts

CLASS B RADIO-FREQUENCY POWER AMPLIFIER

Carrier conditions per tube for use with a maximum modulation factor of 1.0

D-c plate voltage.....	12000	15000	18000	20000	volts
D-c grid voltage.....	-100	-150	-200		volts
D-c plate current.....	2.8	3.5	4.2	5	amperes
Plate input.....				100	kilowatts
Plate dissipation.....				75	kilowatts
Peak r-f grid input voltage.....	500	625	750		volts
Driving power**, approximate.....	0.5	0.75	1.1		kilowatts
Plate power output.....	11	17.5	25		kilowatts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—PLATE-MODULATED

Carrier conditions per tube for use with a maximum modulation factor of 1.0

D-c plate voltage.....	8000	10000	12000	12000	volts
D-c grid voltage.....	-700	-750	-800	-3000	volts
D-c plate current.....	4	4.5	5	5	amperes
D-c grid current, approximate.....	1	1	1	1.25	amperes
Plate input.....				60	kilowatts
Plate dissipation.....				50	kilowatts
Peak r-f grid input voltage, approximate.....	1700	1850	2000		volts
Driving power, approximate.....	1.7	1.85	2		kilowatts
Plate power output.....	24	34	45		kilowatts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Key-down conditions per tube without modulation#

D-c plate voltage.....	12000	15000	18000	20000	volts
D-c grid voltage.....	-800	-900	-1000	-3000	volts
D-c plate current.....	6.25	7.5	8.33	10	amperes
D-c grid current, approximate.....	0.8	0.85	0.9	1	ampere
Plate input.....				200	kilowatts
Plate dissipation.....				100	kilowatts
Peak r-f grid input voltage, approximate.....	2050	2300	2550		volts
Driving power, approximate.....	1.6	2	2.4		kilowatts
Plate power output.....	50	75	100		kilowatts

* Averaged over any audio-frequency cycle.

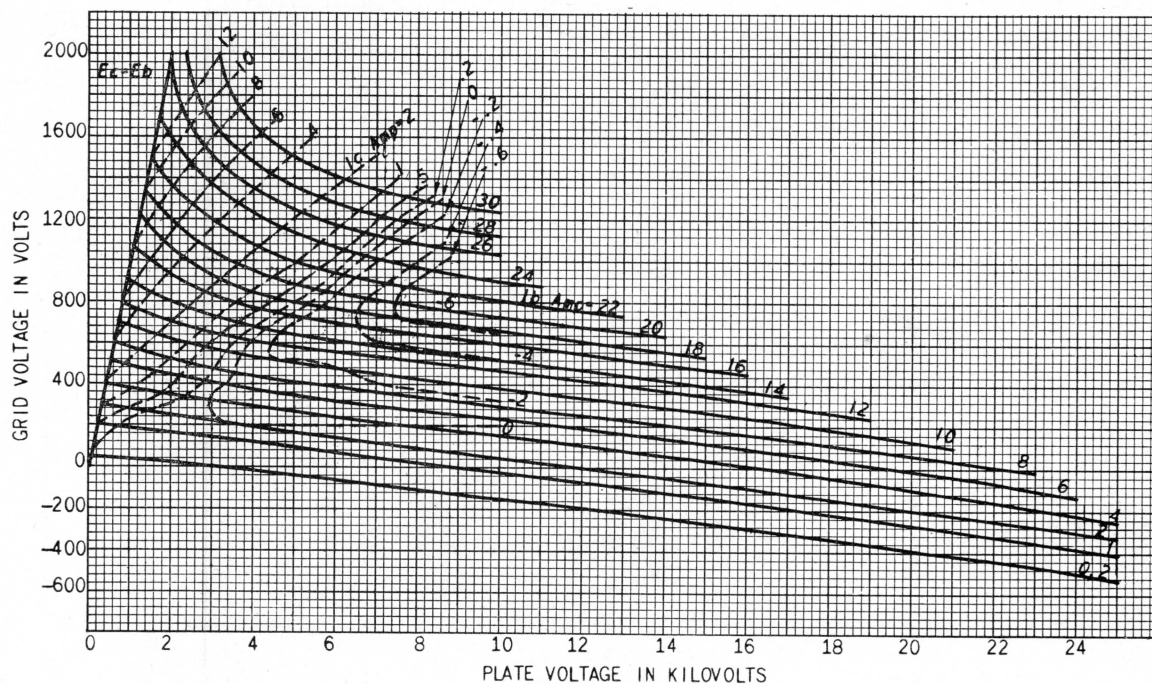
** At crest of audio-frequency cycle.

#Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

APPLICATION NOTES

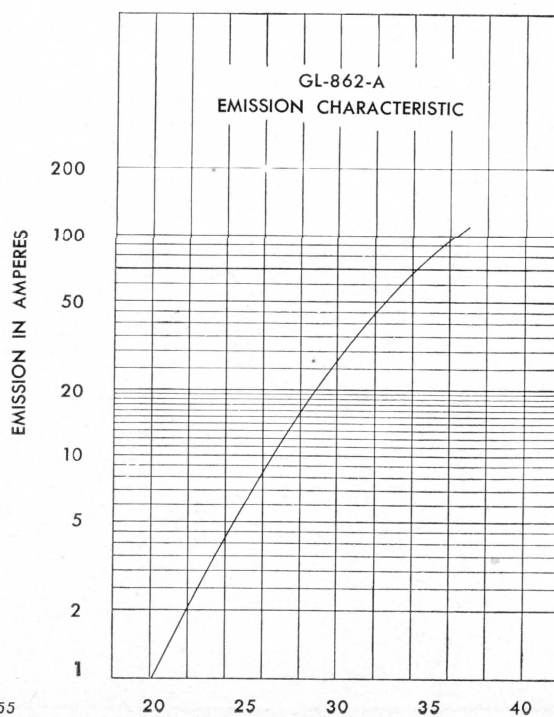
Plate series protective resistors (see paragraph describing plate circuit under Installation in the Instructions)

Series resistor	10	20	40	50 ohms
Maximum power output of rectifier	100	250	640	1600 kilowatts



K-6966424

12-10-45

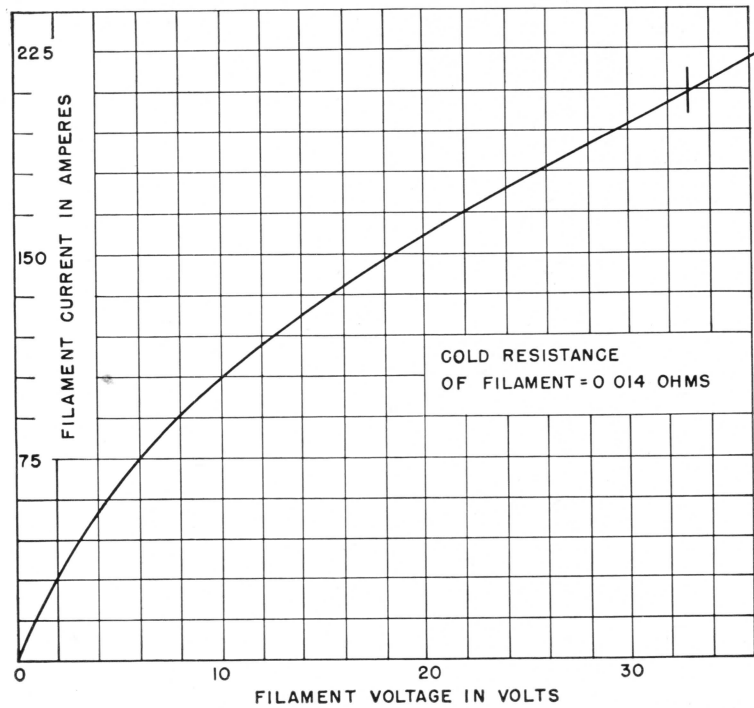
GL-862-A CHARACTERISTICS ($E_f = 33$ VOLTS A-C)

K-8074655

1-9-46

FILAMENT VOLTAGE IN VOLTS (SINGLE-PHASE FILAMENT EXCITATION)

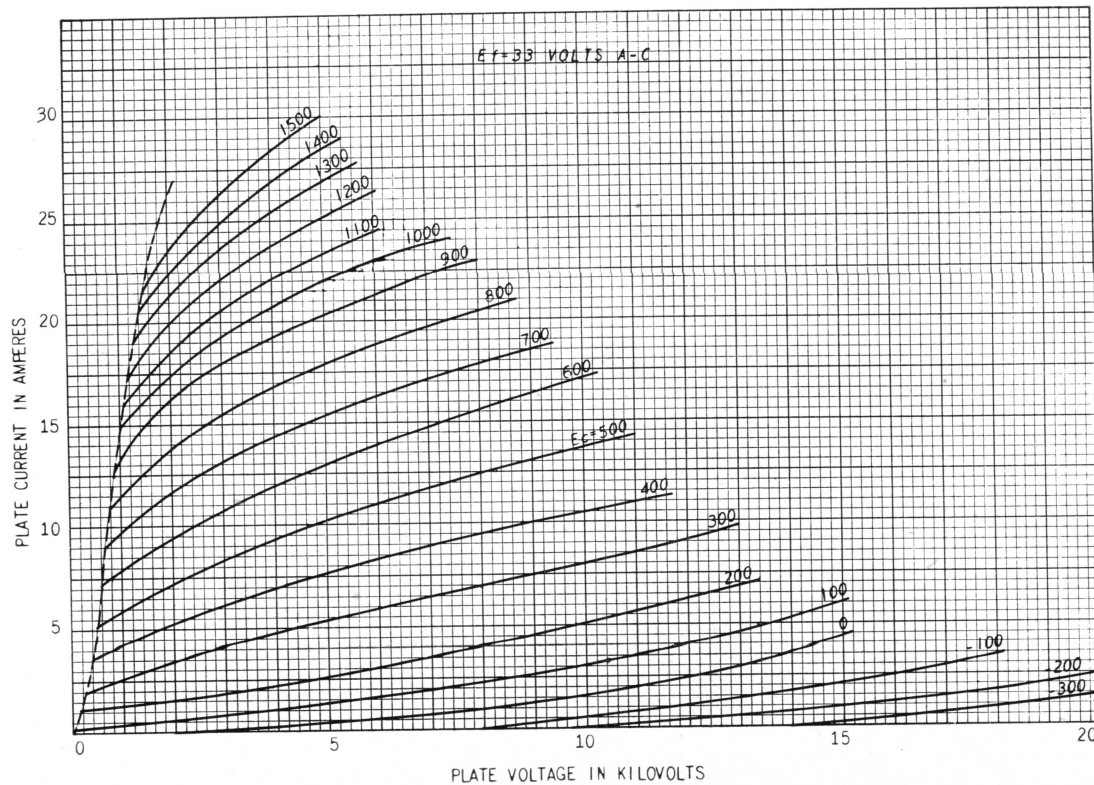
GL-862-A
FILAMENT CHARACTERISTICS



K-8074623

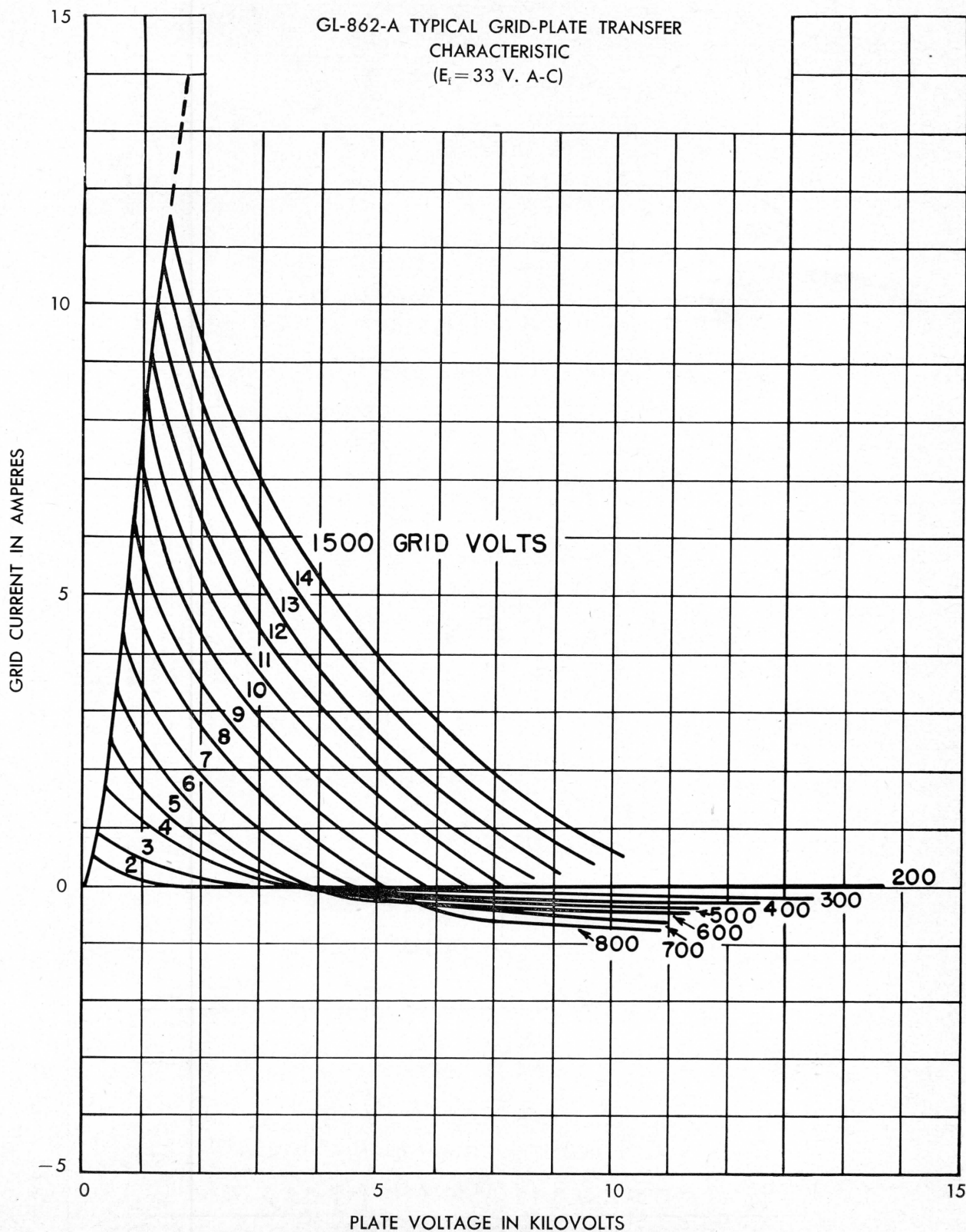
9-26-44

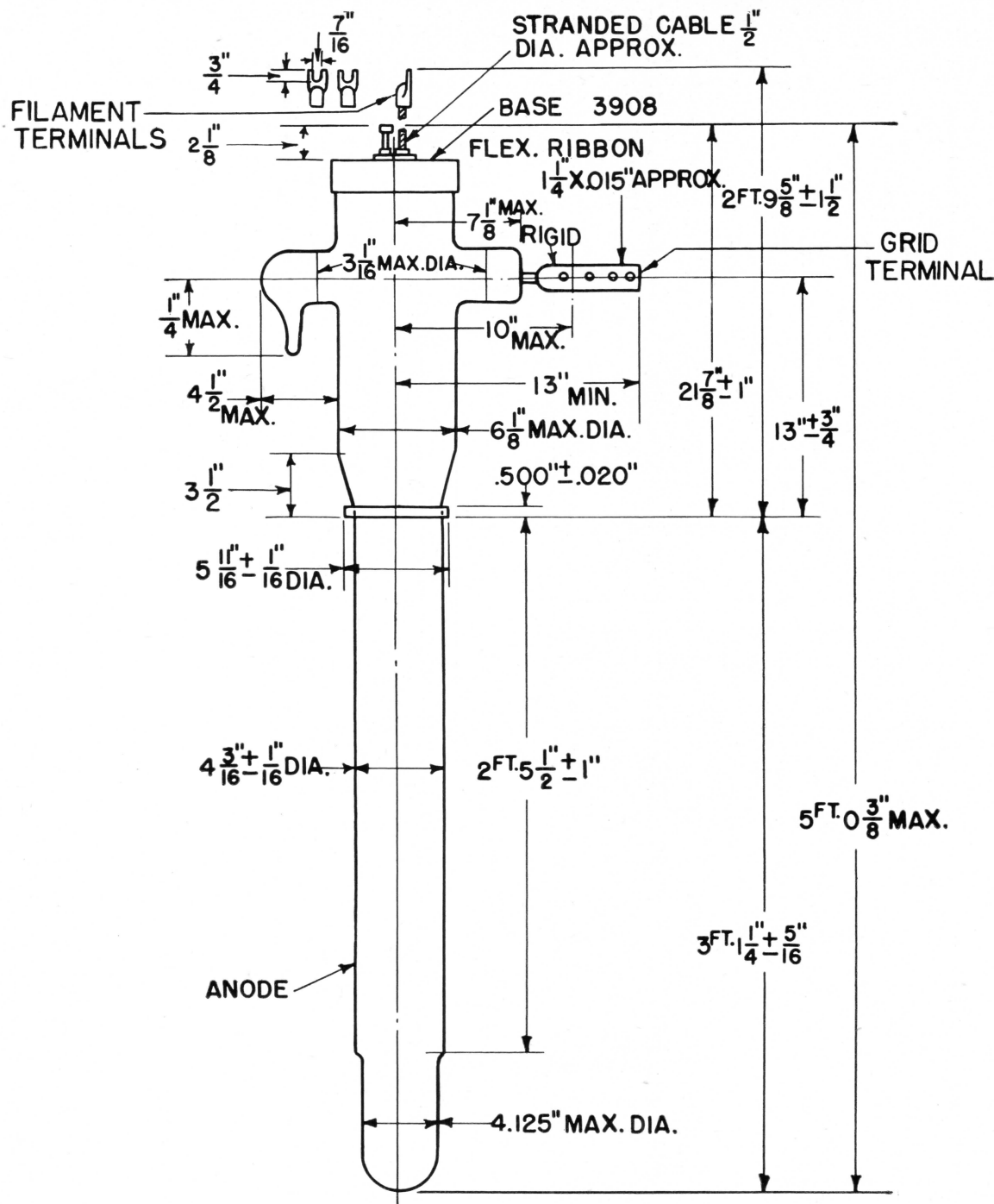
GL-862-A
AVERAGE PLATE CHARACTERISTICS



K-6966423

1-9-46





GL-862-A OUTLINE

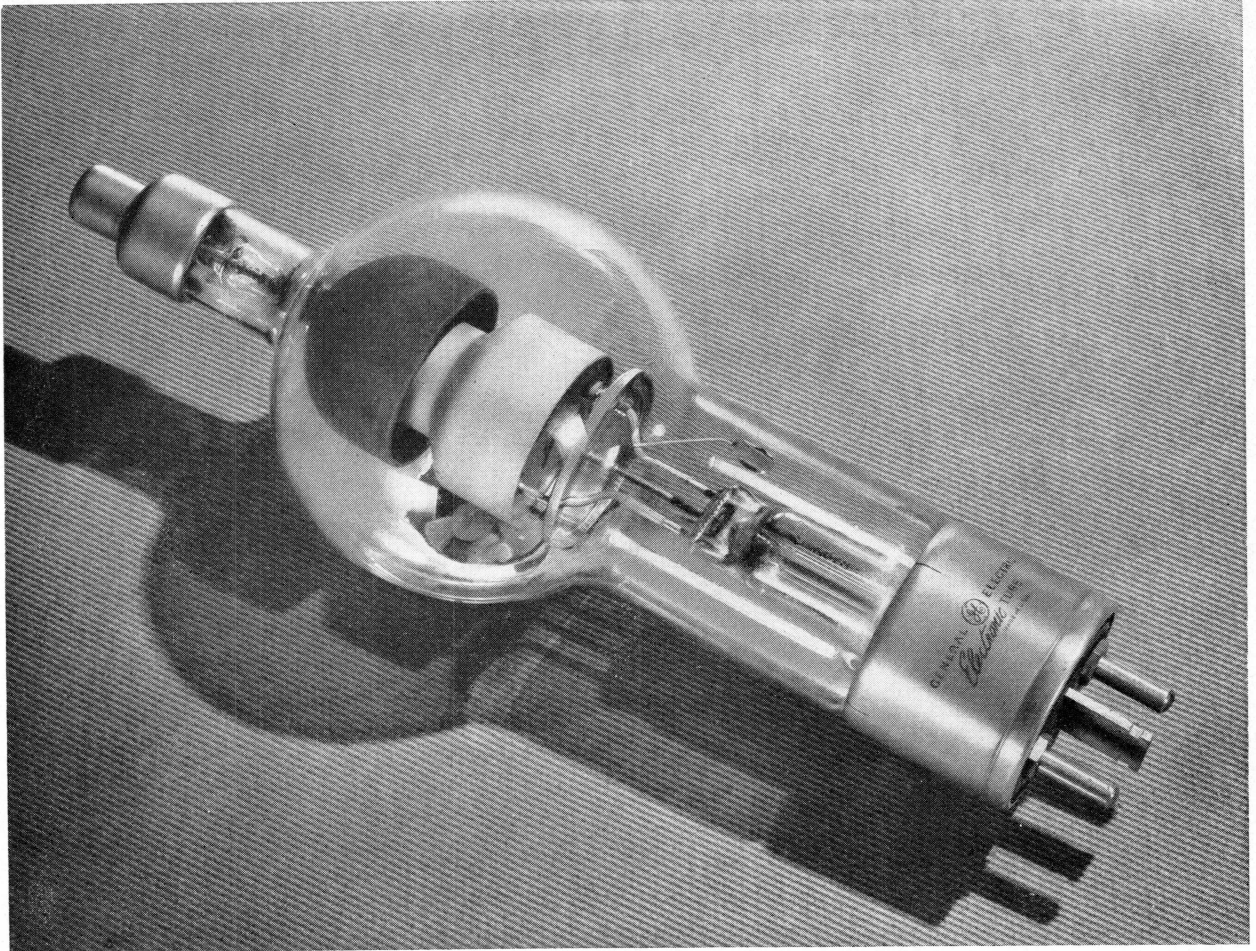
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9-23-44

ELECTRONIC COMPONENTS DIVISION

GENERAL  **ELECTRIC**

Schenectady 5, N. Y.



PHATRON

The GL-869-B is a half-wave, mercury-vapor rectifier tube for use in broadcast transmitters and other applications where high d-c voltages are re-

quired. The cathode is designed for economical, long-life operation.

TECHNICAL INFORMATION

GENERAL

Electrical	Minimum	Bogey	Maximum
Filament Voltage.....	4.75	5.0	5.25 Volts
Filament Current at 5.0 Volts.....		19	21 Amperes
Cathode Heating Time.....	60	....	.... Seconds
Anode Voltage Drop.....		15	 Volts
Critical Anode Voltage.....		....	100 Volts

TECHNICAL INFORMATION (CONT'D)

Mechanical

Type of Cooling—Convection or Forced Air

Equilibrium Condensed-Mercury Temperature Rise above Ambient

At Full Load, approximate 20 C

At No Load, approximate 15 C

Mounting Position—Vertical, Base Down

Net Weight, maximum 1.6 Pounds

MAXIMUM RATINGS, Absolute Values

Maximum Peak Inverse Anode Voltage 10,000 15,000 20,000 Volts

Condensed-Mercury Temperature Limits 30 to 60 30 to 50 30 to 40 C

Maximum Cathode Current

Peak

In-Phase Operation 10 10 10 Amperes

Quadrature Operation 20 20 10 Amperes

Average

In-Phase Operation 2.5 2.5 2.5 Amperes

Quadrature Operation 5 5 2.5 Amperes

Maximum Averaging Time 30 30 30 Seconds

Fault 100 100 100 Amperes

Maximum Duration 0.1 0.1 0.1 Seconds

Maximum Frequency 150 150 150 Cycles per Second

□ Denotes an addition.

□ X-RAY WARNING NOTICE

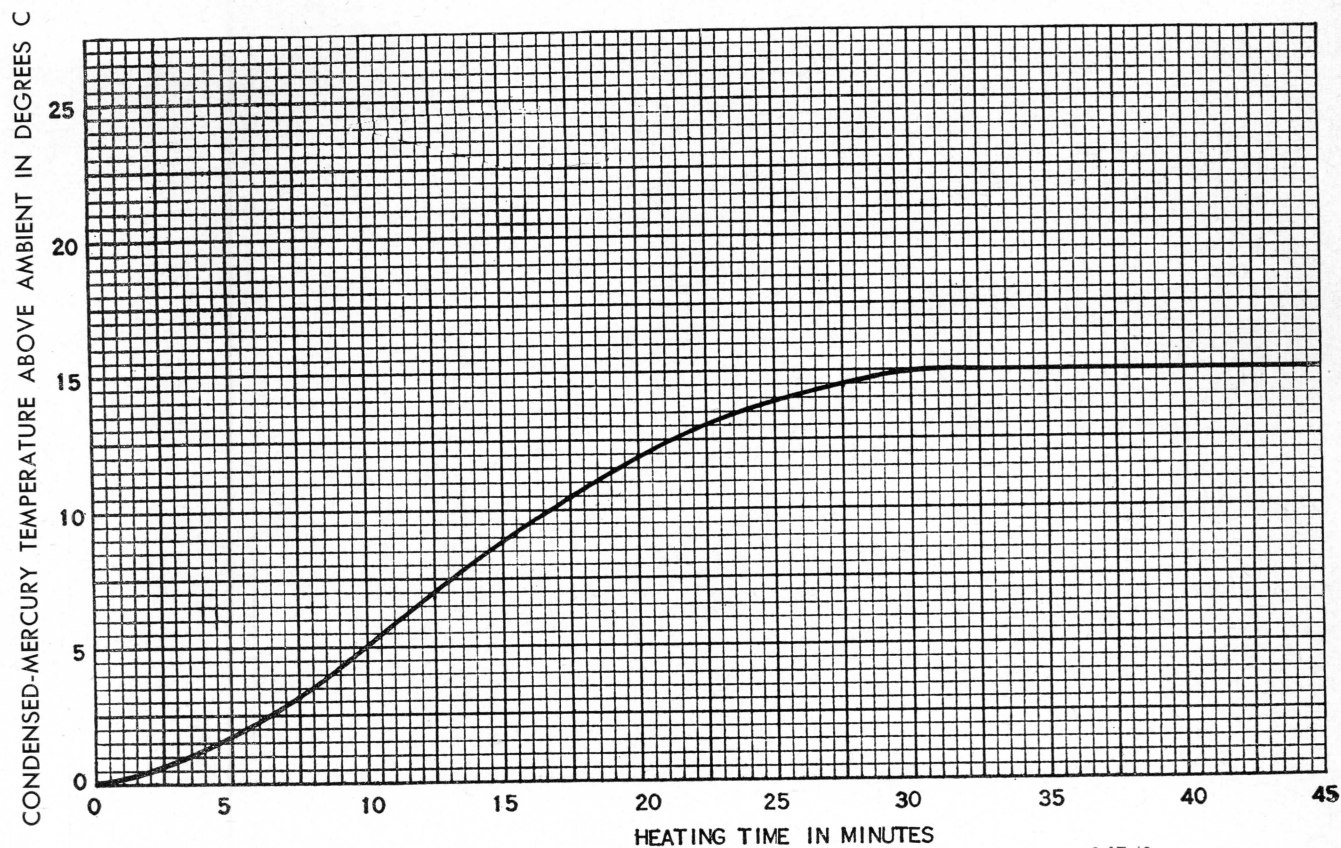
If the GL-869-B is operated at anode voltages in excess of 16 kilovolts, x-ray radiation shielding may be necessary to protect the user against possible danger of personal injury from prolonged exposure at close range. For further information consult the following references or other standard texts on the subject:

(a) *X-Ray Protection Design*, Handbook No. 50. National Bureau of Standards, Washington, D. C.

(b) *X-Ray Protection*, Handbook No. 60. National Bureau of Standards, Washington, D. C.

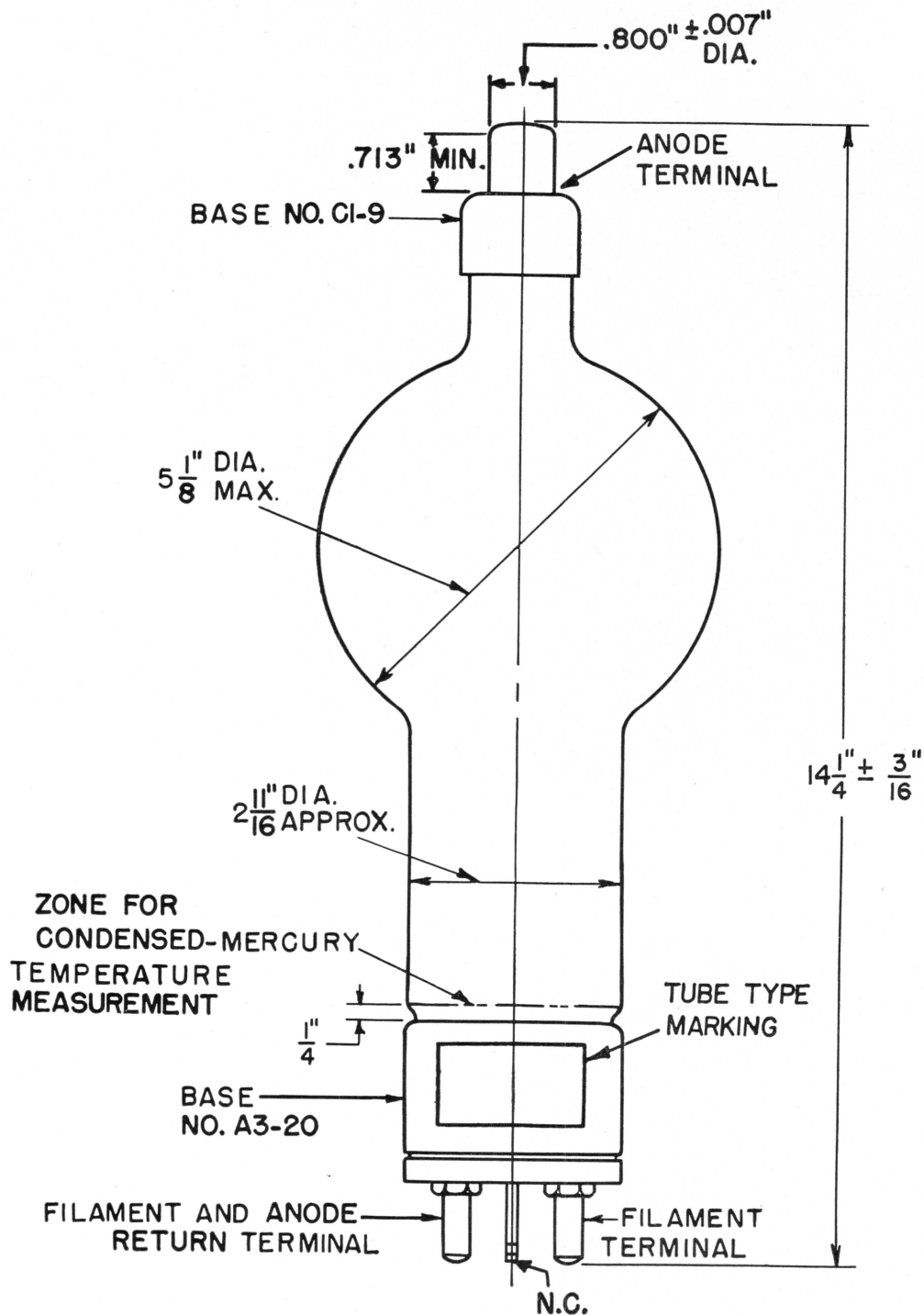
The above references are available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

RATE OF RISE OF
CONDENSED-MERCURY TEMPERATURE
 $E_f = 4.75$ VOLTS



K-69087-72A133

2-17-49



K-4909011

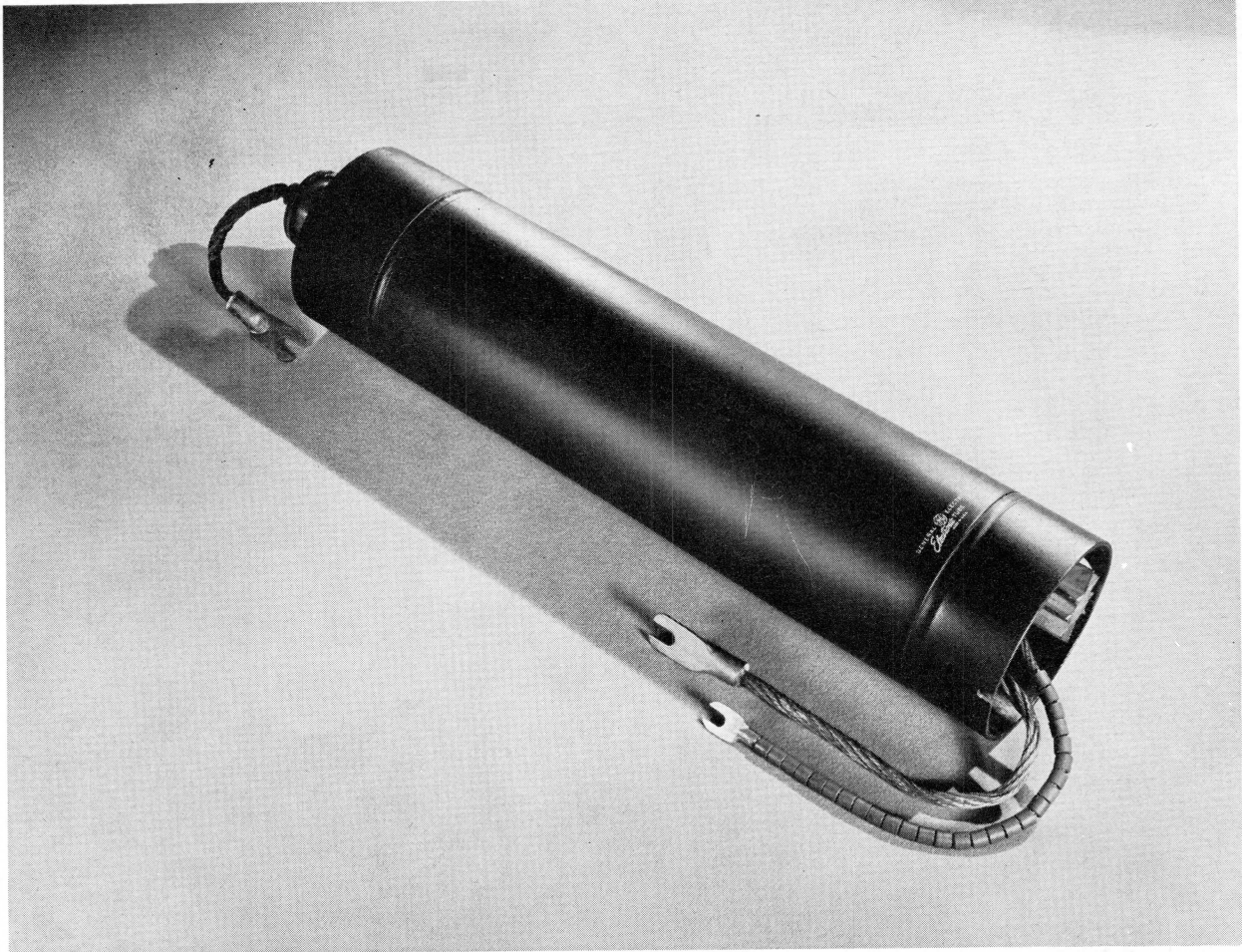
9-26-50

ELECTRONIC COMPONENTS DIVISION

GENERAL  ELECTRIC

Schenectady 5, N. Y.

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PHANOTRON

HALF-WAVE
75 AMPERES
MERCURY-VAPOR

The GL-870-A is a heavy-duty, half-wave, mercury-vapor rectifier tube containing a heater-cathode of the equipotential type. The cathode consists

of a coated cylinder heated by means of an enclosed tungsten filament (heater). The cathode is connected to one side of the heater within the tube.

TECHNICAL INFORMATION

GENERAL

Number of Electrodes.....2

Electrical

Cathode—Coated Unipotential

Voltage.....	5.0	Volts
Current, approximate.....	65.0	Amperes
Transformer Power, for design purposes.....	400	Watts
Heating Time, typical.....	30	Minutes
Peak Voltage Drop, typical.....	16	Volts

Mechanical

Net Weight, approximate.....	25	Pounds
Shipping Weight, approximate.....	40	Pounds
Mounting Position—Vertical, Leads Down		

Thermal

Type of Cooling—Forced Air		
Corresponding Mercury Temperature.....	35-40	C
Recommended Temperature, condensed mercury.....	35-40	C

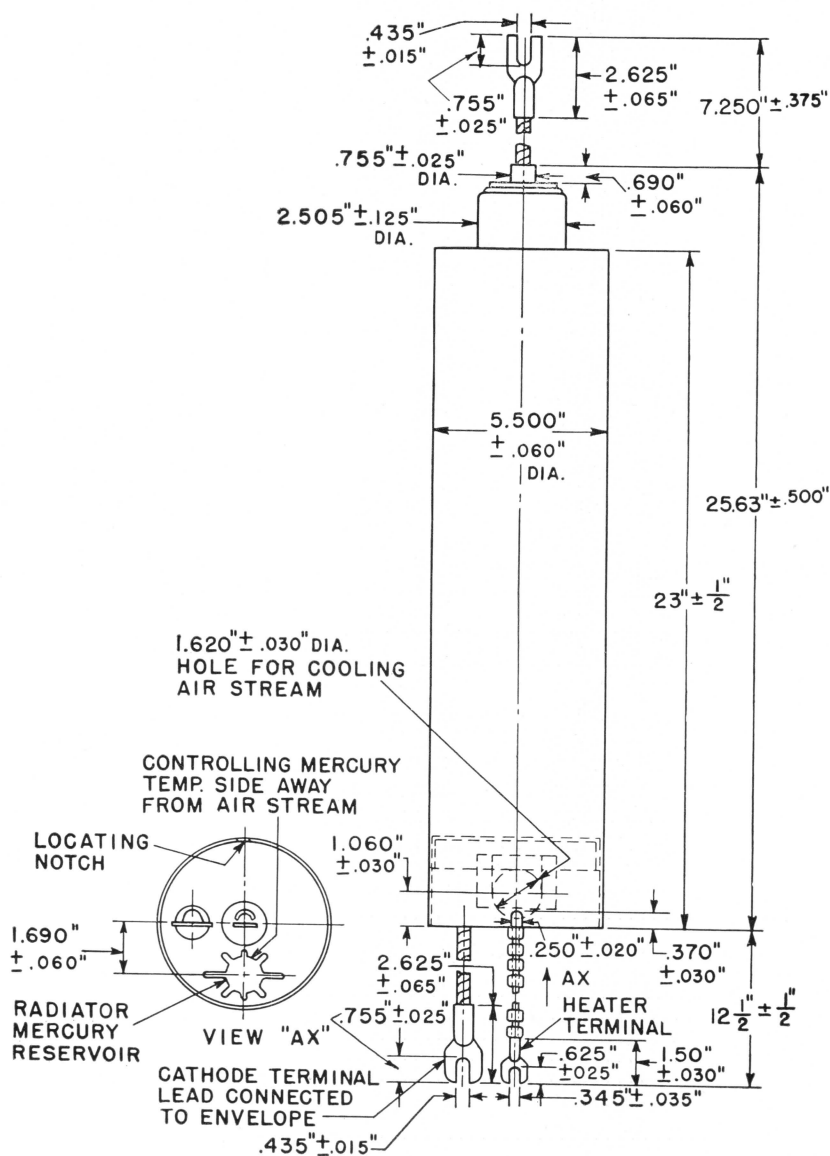
GENERAL  ELECTRIC

Supersedes ETX-177 dated 5-46

TECHNICAL INFORMATION (CONT'D)

MAXIMUM RATINGS

Maximum Peak Inverse Anode Voltage, 150 cycles or less	16,000 Volts	7500	Volts
Maximum Anode Current			
Instantaneous, 25 cycles and above		450	Amperes
Average		75	Amperes
Surge, for design only		4500	Amperes
Maximum Time of Averaging Current		60	Seconds
Maximum Time of Surge Anode Current		0.2	Second



K-6979159

1-9-46

ELECTRONIC COMPONENTS DIVISION

GENERAL ELECTRIC

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TRIODE

The GL-880 is a three-electrode tube designed for use as a radio-frequency amplifier, oscillator, or Class B modulator. The anode is water-cooled

and capable of dissipating 20 kilowatts. The cathode is a pure-tungsten filament. Maximum ratings apply up to 25 megacycles.

◆ TECHNICAL INFORMATION

GENERAL

Electrical

	Minimum	Bogey	Maximum
Filament voltage.....		12.6	13.2 volts
Filament current.....	300	320	330 amperes
Filament starting current.....			480 amperes
Filament cold resistance.....		0.003	ohms
Amplification factor, $I_b = 2.0$ amp, $E_c = -100$ v...	17	20	23
Interelectrode capacitances			
Grid—Plate.....	21	24	27 uuf
Grid—Filament.....	28.8	35	41.2 uuf
Plate—Filament.....	1.0	2.0	3.0 uuf

◆ Technical information completely revised.


Electronic
TUBE

GENERAL  ELECTRIC

Supersedes ETX-179 dated 5-46

TECHNICAL INFORMATION (CONT'D)

Mechanical

Mounting position—Vertical, anode down

Type of cooling—Water and forced air

Water flow on anode.....20 gpm

Maximum outgoing water temperature.....70 C

Air flow (to bulb and seals)*.....20 cfm

Maximum glass temperature.....150 C

Gasket Type No. JTC-11

Net weight, approximate.....7 pounds

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

AUDIO-FREQUENCY POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum ratings, absolute values.....	CCS†	
D-c plate voltage.....	10,500 max	volts
Maximum signal d-c plate current†.....	5 max	amperes
Maximum signal plate input†.....	40 max	kilowatts
Plate dissipation†.....	15 max	kilowatts
Typical operation	CCS†	CCS†
Unless otherwise specified, values are for two tubes		
D-c plate voltage.....	7500	10,000 volts
D-c grid voltage.....	—340	—450 volts
Peak a-f grid-to-grid voltage.....	1450	1680 volts
Zero signal d-c plate current.....	1.0	1.0 amperes
Maximum signal d-c plate current.....	6.7	7.0 amperes
Effective load resistance, plate to plate.....	2300	3100 ohms
Maximum signal driving power, approximate.....	490	540 watts
Maximum signal power output, approximate.....	31.5	46 kilowatts

*From a 3-inch diameter nozzle.

†Continuous Commercial Service.

‡Averaged over any audio-frequency cycle of sine-wave form.

RADIO-FREQUENCY POWER AMPLIFIER—CLASS B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum ratings, absolute values	CCS†	
D-c plate voltage.....	10,500 max	volts
D-c plate current.....	4.0 max	amperes
Plate input.....	32.0 max	kilowatts
Plate dissipation.....	20.0 max	kilowatts
Typical operation	CCS†	CCS†
D-c plate voltage.....	7500	10,000 volts
D-c grid voltage.....	—340	—460 volts
Peak r-f grid voltage.....	570	595 volts
D-c plate current.....	3.3	2.75 amperes
D-c grid current, approximate.....	0.013	0.009 amperes
Driving power, approximate§.....	1250	900 watts
Power output, approximate.....	8	9 kilowatts

PLATE-MODULATED RADIO-FREQUENCY POWER AMPLIFIER—CLASS C TELEPHONY

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum ratings, absolute values	CCS†	
D-c plate voltage.....	10,500 max	volts
D-c grid voltage.....	—1200 max	volts
D-c plate current.....	3.6 max	amperes
D-c grid current.....	0.8 max	amperes
Plate input.....	36 max	kilowatts
Plate dissipation.....	12 max	kilowatts
Typical operation	CCS†	CCS†
D-c plate voltage.....	7500	10,000 volts
D-c grid voltage.....	—1000	—1200 volts
Peak r-f grid voltage.....	1560	1840 volts
D-c plate current.....	3.0	3.6 amperes
D-c grid current, approximate.....	0.57	0.64 amperes
Driving power, approximate.....	850	1100 watts
Power output, approximate.....	16.0	27.0 kilowatts

TECHNICAL INFORMATION (CONT'D)

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

Key-down conditions per tube without amplitude modulation π

Maximum ratings, absolute values	CCS†	CCS†	
D-c plate voltage	10,500	15,000 $\square$ max	volts
D-c grid voltage	-1200	-1600 $\square$ max	volts
D-c plate current	6.0	4.5 $\square$ max	amperes
D-c grid current	0.8	1.0 $\square$ max	amperes
Plate input	60	67.5 $\square$ max	kilowatts
Plate dissipation	20	20.0 $\square$ max	kilowatts
Typical operation	CCS†	CCS†	CCS†
D-c plate voltage	7500	10,000	10,000 volts
D-c grid voltage	-600	-800	-1000 volts
Peak r-f grid voltage	1250	1460	1830 volts
D-c plate current	4.8	4.5	6.0 amperes
D-c grid current, approximate	0.79	0.78	0.8 amperes
Driving power, approximate	920	1000	1500 watts
Power output, approximate	24.0	33.0	40.00 kilowatts

†Continuous Commercial Service.

§At crest of audio-frequency cycle with modulation factor of 1.0.

 π Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of the carrier conditions. $\square$ These ratings apply only at a frequency of 1500 kilocycles or less.

Maximum ratings apply up to 25 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced according to the tabulation below (other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at these frequencies.

Frequency	25	50	100 megacycles
Percentage of maximum rated plate			
Voltage and plate input			
Class B—Maximum plate voltage	100	80	60 per cent
Maximum plate input	100	94	75 per cent
Class C—Plate modulated	100	72	45 per cent
Class C—Unmodulated	100	75	50 per cent

■ Revised curve.

7-21-48

61-B80
GRID CHARACTERISTICS
 $E_r = 12.5$ VOLTS A-C

Y-axis: GRID CURRENT IN AMPERES (0 to 12)
X-axis: PLATE VOLTAGE IN KILOVOLTS (0 to 10)

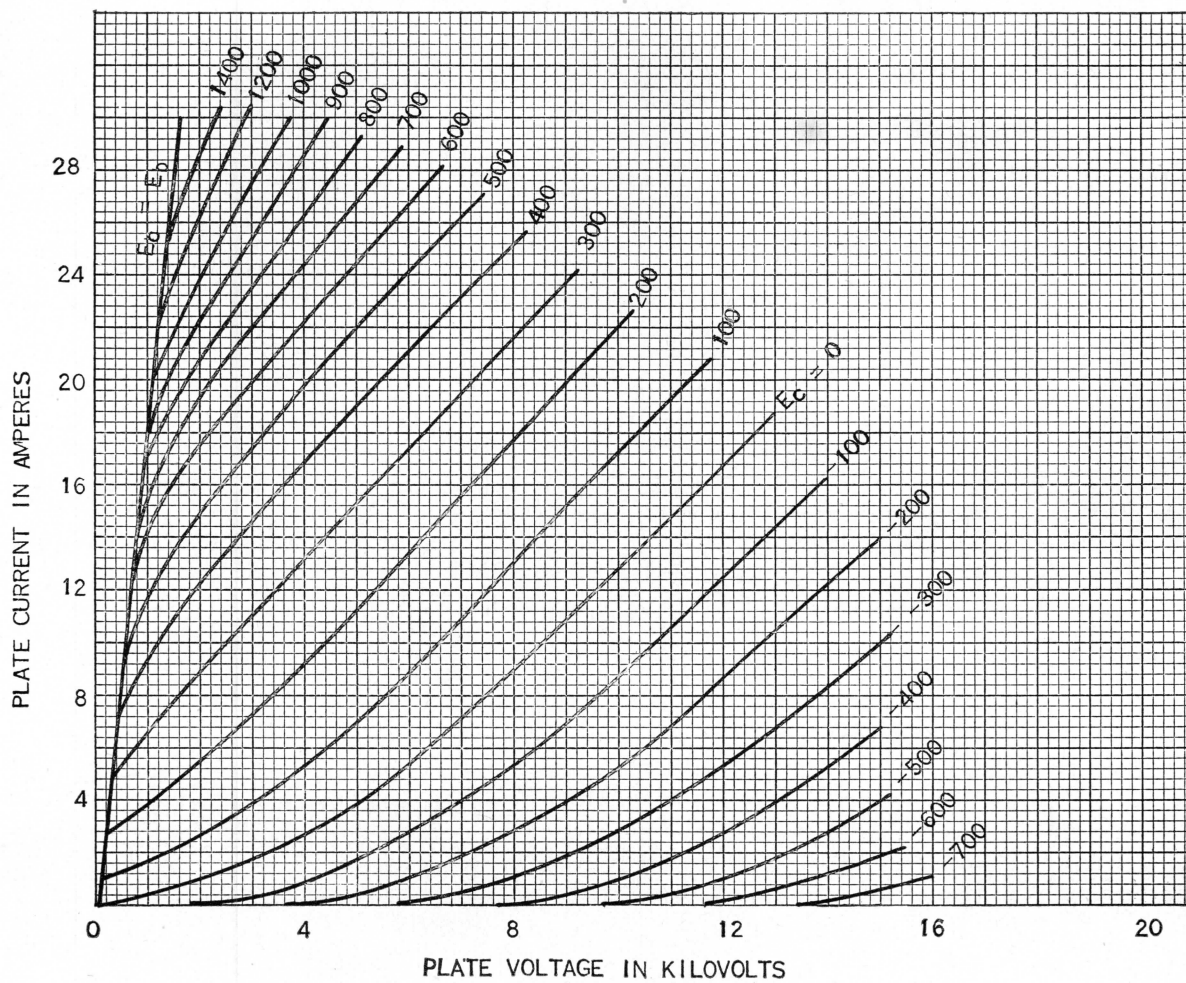
Curves are labeled with grid voltage (E_g) values: 1600, 1400, 1200, 1000, 900, 800, 700, 600, 500, 400, 300, 200, 100.

K-69087-72A245

7-21-48

▲GL-880

PLATE CHARACTERISTICS

 $E_i = 12.6$ VOLTS A-C

K-69087-72A243

7-21-48

▲New curve

9-49

FILAMENT TERMINAL

GRID TERMINAL

FILAMENT TERMINAL

GRID TERMINAL

$2\frac{1}{8}$ "

$2\frac{3}{8}$ "

$\frac{5}{8}$ " MIN.
STRAIGHT SIDE

$\frac{3}{4}$ " MIN.

$.437 \pm .007$ " DIA.

$8\frac{3}{16} \pm \frac{3}{16}$ "

5" MAX. DIA.

7" MAX. DIA.

$3\frac{7}{8} \pm \frac{1}{16}$ "

$5\frac{21}{32} \pm \frac{9}{32}$ " DIA.

$3.170 \pm .035$ " DIA.

$4.062 \pm .045$ " DIA.

12° APPROX.

$1\frac{7}{8} \pm \frac{1}{4}$ "

$.500 \pm .020$ "

$4.187 \pm .032$ " DIA.

$5.750 \pm .032$ " DIA.

ANODE

$3 \pm \frac{1}{8}$ "

$\frac{1}{4}"$ MIN.

NOTE:
THE TUBE SHALL BE TO THE DIMENSIONS OF THE TABLE OF TOLERANCES FOR VACUUM TUBES. DIMENSIONS IN PARENTHESES ARE NOT TO BE USED UNLESS SPECIFICALLY SO INDICATED. DIMENSIONS IN CIRCLES 2.0 AND 2.5 ARE NOT TO BE USED UNLESS SPECIFICALLY SO INDICATED.

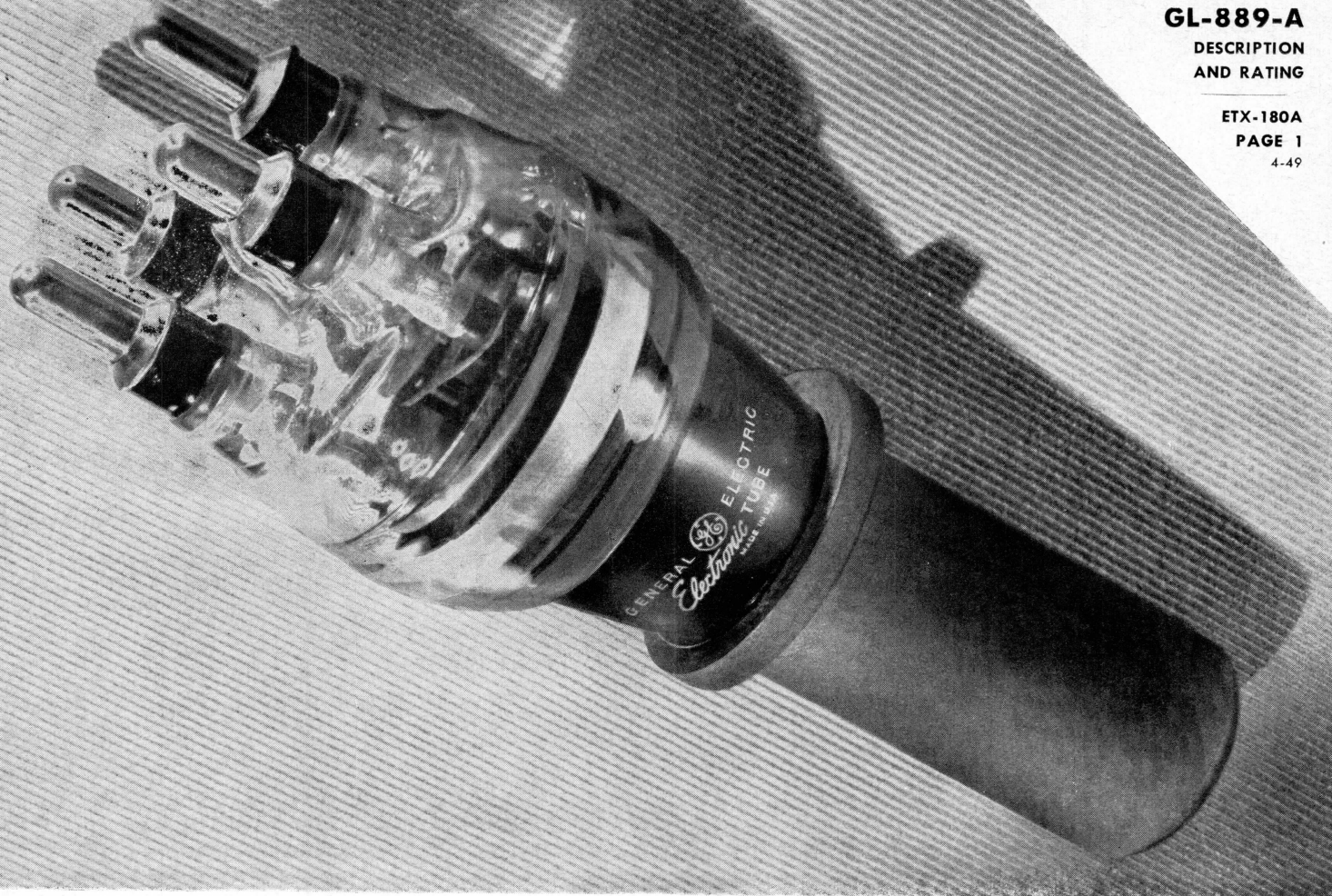
THE TUBE BASE SHALL BE CAPABLE OF ENTERING TO A DISTANCE OF $\frac{5}{8}$ " IN A FLAT PLATE GAGE HAVING FOUR HOLES $.536" \pm .001"$ DIA. ARRANGED ALTERNATELY ON TWO CONCENTRIC CIRCLES $2.125" \pm .001"$ AND $2.375" \pm .001"$ DIA. AT ANGLES OF $90^\circ \pm 10^\circ$.

8-18-45

GENERAL  ELECTRIC

Schenectady 5, N. Y.

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TRIODE

The GL-889-A is a three-electrode power tube designed for use as a radio-frequency, amplifier, oscillator, or Class B modulator. The plate is water-cooled and is capable of dissipating 5

kilowatts, depending upon the class of service. The design of the mount and terminal connections minimizes lead inductance and makes the tube particularly suitable for high-frequency applications.

TECHNICAL INFORMATION

GENERAL

Electrical	Minimum	Begey	Maximum
Filament voltage.....	—	11.0	11.5 volts
Filament current at bogey voltage.....	110	120	128 amperes
Filament starting current.....	—	—	180 amperes
Filament cold resistance.....	—	0.008	— ohm
Amplification factor, at $I_b = 1.0$ amp.			
$E_c = -100$ volts.....	17	21	25
Interelectrode capacitance			
Grid-plate.....	15	17.5	20 micromicrofarads
Grid-filament.....	19.2	23.3	27.4 micromicrofarads
Plate-filament.....	1.8	2.7	3.6 micromicrofarads

GENERAL  ELECTRIC

Supersedes ETX-180 dated 5-46


Electronic
TUBE

TECHNICAL INFORMATION (CONT'D)

Mechanical

Mounting position—vertical, anode down

Type of cooling—water and forced air

Water flow on anode 6 gallons per minute

Maximum outgoing water temperature 70 centigrade

Air flow* (to bulb) 15 cubic feet per minute

Maximum glass temperature 150 centigrade

Net weight, approximate 2 pounds

* Air to be directed at the top of tube from a 3-inch-diameter nozzle.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

AUDIO-FREQUENCY POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum ratings, absolute values	CCS*			
D-c plate voltage	8500	maximum	volts	
Maximum signal d-c plate current†	2	maximum	amperes	
Maximum signal plate input†	12	maximum	kilowatts	
Plate dissipation†	5	maximum	kilowatts	
Typical operation	CCS*	CCS*	CCS*	
Unless otherwise specified, values are for two tubes				
D-c plate voltage	5000	6000	7500	volts
D-c grid voltage	—180	—230	—300	volts
Peak a-f grid-to-grid voltage	1460	1680	1700	volts
Zero signal d-c plate current	0.4	0.4	0.4	ampere
Maximum signal d-c plate current	3.2	3.6	3.2	amperes
Effective load resistance, plate-to-plate	2520	3680	5000	ohms
Maximum signal driving power, approximate	170	180	150	watts
Maximum signal power output, approximate	8.8	12	15	kilowatts

† Averaged over any audio-frequency cycle of sine-wave form.

RADIO-FREQUENCY POWER AMPLIFIER—CLASS B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum ratings, absolute values	CCS*			
D-c plate voltage	8500	maximum	volts	
D-c plate current	1.0	maximum	ampere	
Plate input	7.5	maximum	kilowatts	
Plate dissipation	5	maximum	kilowatts	
Typical operation	CCS*	CCS*		
D-c plate voltage	6000	7500	volts	
D-c grid voltage	—250	—300	volts	
Peak r-f grid voltage	460	500	volts	
D-c plate current	0.9	0.9	ampere	
D-c grid current, approximate	0.003	0.005	ampere	
Driving power, approximate|| . . . . .	95	80	watts	
Power output, approximate	1.5	2	kilowatts	

|| At crest of audio-frequency cycle with modulation factor of 1.0

PLATE-MODULATED RADIO-FREQUENCY POWER AMPLIFIER—CLASS C TELEPHONY

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum ratings, absolute values	CCS**			
D-c plate voltage	6000	maximum	volts	
D-c grid voltage	1000	maximum	volts	
D-c plate current	1.0	maximum	ampere	
D-c grid current	0.25	maximum	ampere	
Plate input	6	maximum	kilowatts	
Plate dissipation	3	maximum	kilowatts	

TECHNICAL INFORMATION (CONT'D)

Typical operation	CCS*	CCS*	
D-c plate voltage	5000	6000	volts
D-c grid voltage	-800	-900	volts
Peak r-f grid voltage	1300	1420	volts
D-c plate current	0.9	1.0	ampere
D-c grid current, approximate	0.12	0.1	ampere
Driving power, approximate	155	140	watts
Power output, approximate	2.75	4	kilowatts

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

Key-down Conditions Per Tube Without Amplitude Modulation

Maximum ratings, absolute values	CCS*	CCS*	CCS*
D-c plate voltage	8500	maximum	volts
D-c grid voltage	-1000	maximum	volts
D-c plate current	2	maximum	amperes
D-c grid current	0.25	maximum	ampere
Plate input	16	maximum	kilowatts
Plate dissipation	5	maximum	kilowatts
Typical operation	CCS*	CCS*	CCS*
D-c plate voltage	5000	6000	7500 volts
D-c grid voltage	-500	-600	-800 volts
Peak r-f grid voltage	1200	1460	1830 volts
D-c plate current	1.5	1.8	2 amperes
D-c grid current, approximate	0.19	0.21	0.24 ampere
Driving power, approximate	220	290	400 watts
Power output, approximate	5	7	10 kilowatts

Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of the carrier conditions.

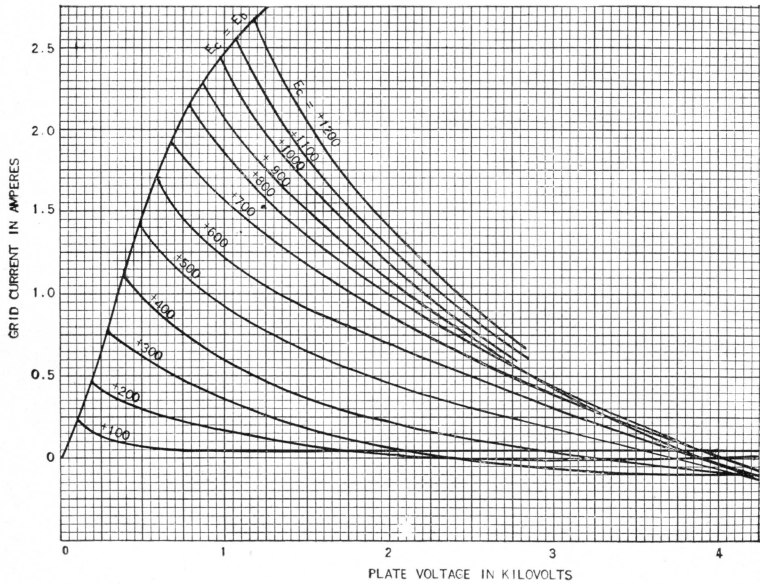
*CCS—Continuous commercial service.

APPLICATION NOTES

* GL-889-A can be operated at maximum ratings in all classes of service at frequencies as high as 50 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under TECHNICAL INFORMATION.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 150 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

Frequency	50	100	150 megacycles
Percentage of maximum rated plate voltage and plate input			
Class B	100	83	72 per cent
Class C plate modulated	100	75	60 per cent
Class C unmodulated—maximum plate voltage	100	78	65 per cent
Class C unmodulated—maximum plate input	100	70	50 per cent

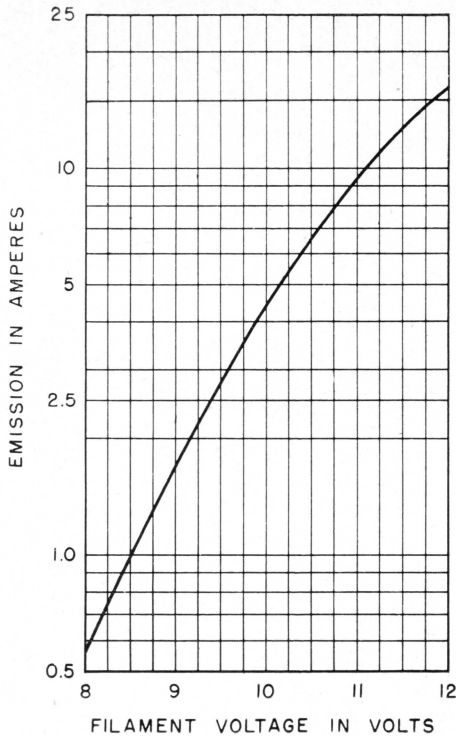
GL-889-A
TYPICAL GRID-PLATE TRANSFER CHARACTERISTIC
 $E_f = 11$ VOLTS A-C



K-8074636

3-5-48

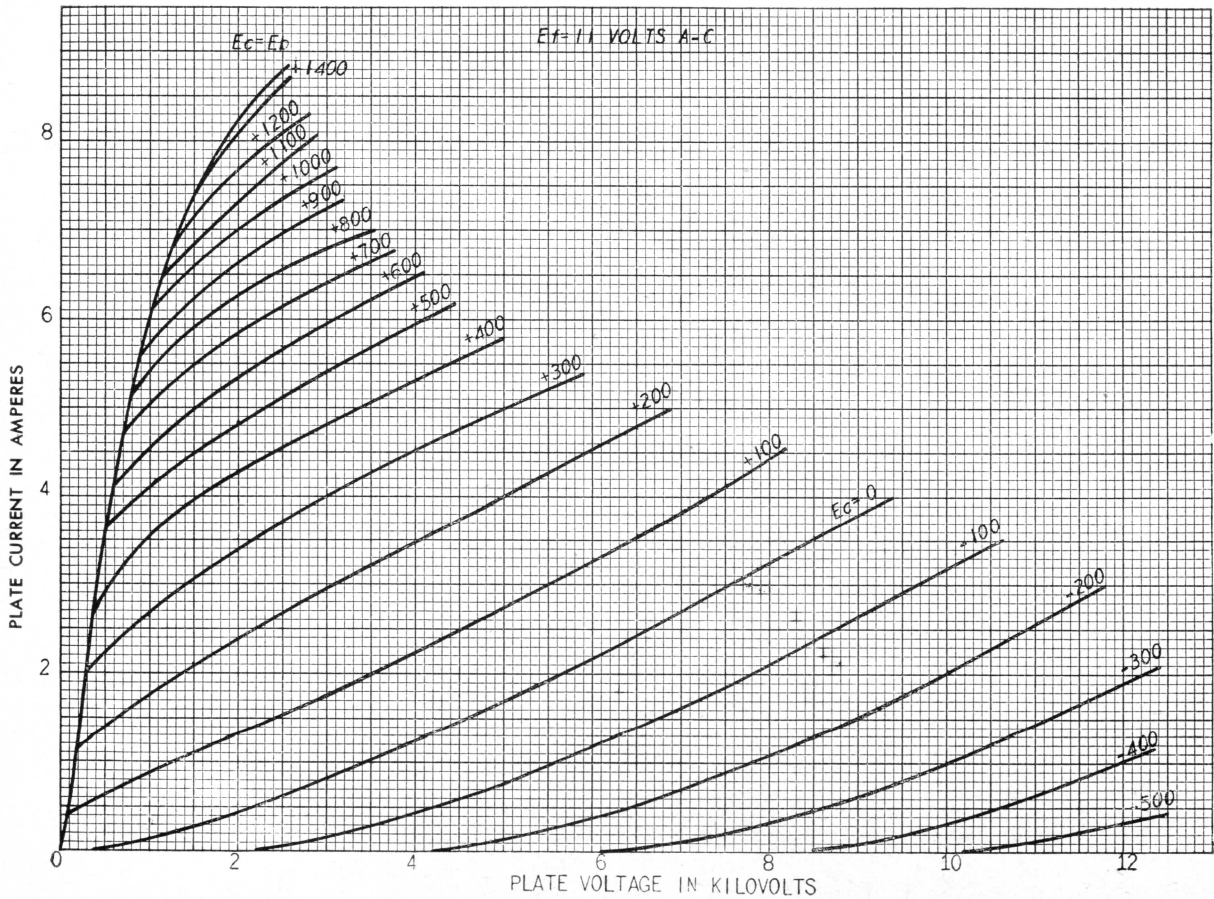
GL-889-A EMISSION CHARACTERISTICS



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12-10-45

GL-889-A
AVERAGE PLATE CHARACTERISTIC

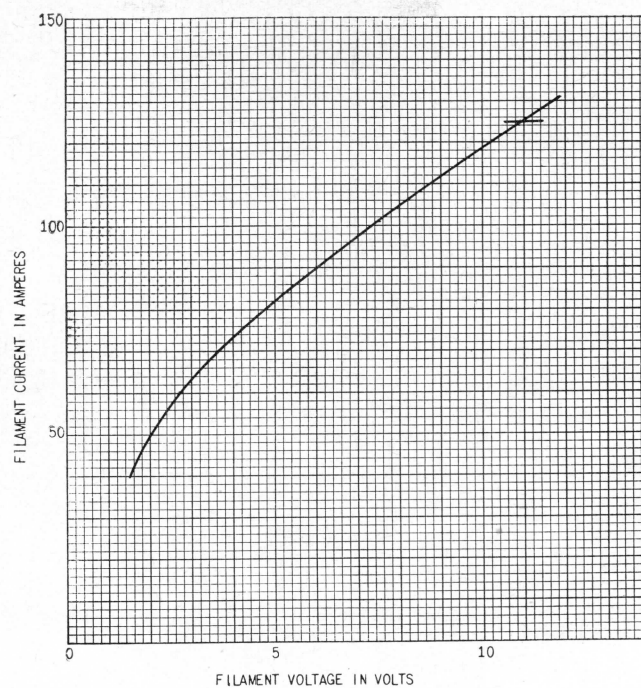


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3-5-48

GL-889-A AVERAGE FILAMENT CHARACTERISTICS

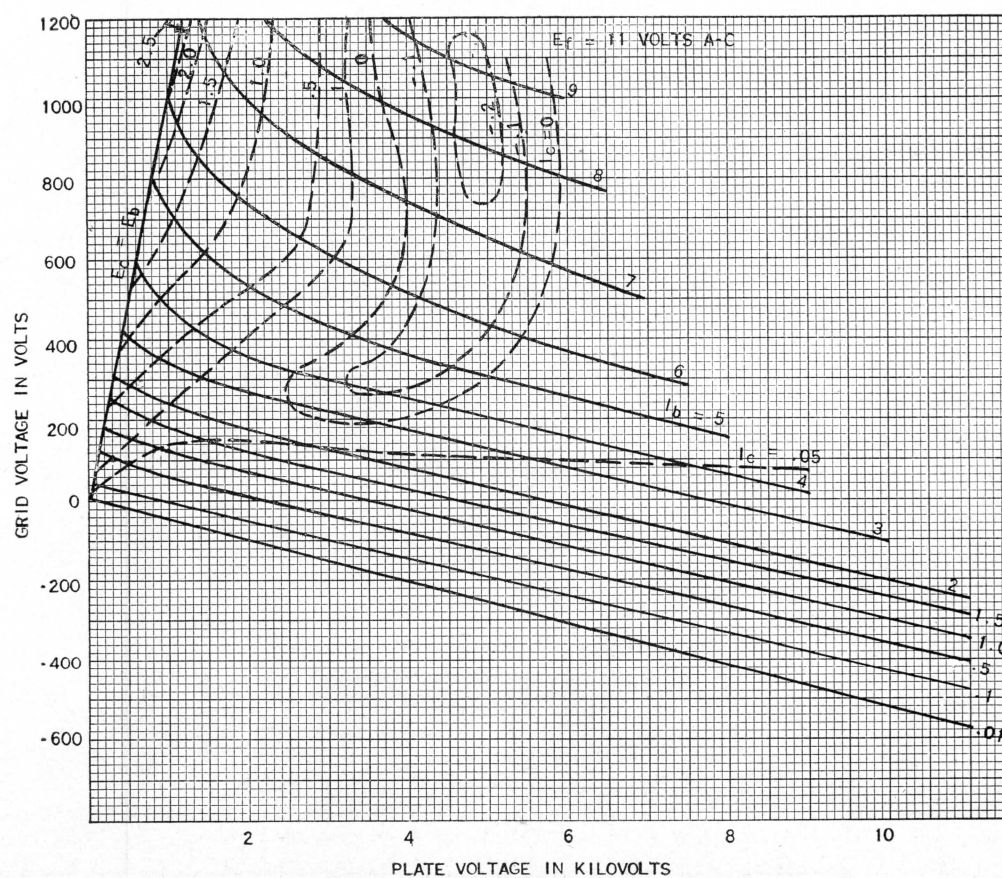
COLD RESISTANCE = 0.0003 OHM



K-8074634

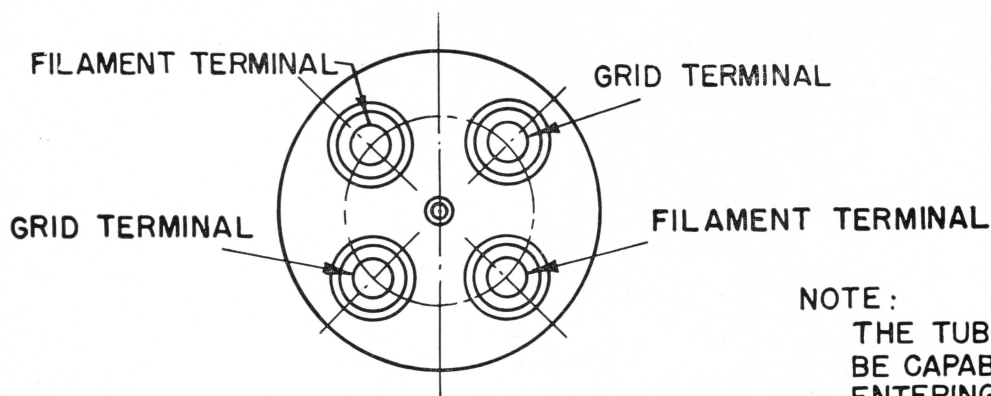
1-9-46

GL-889-A CHARACTERISTIC



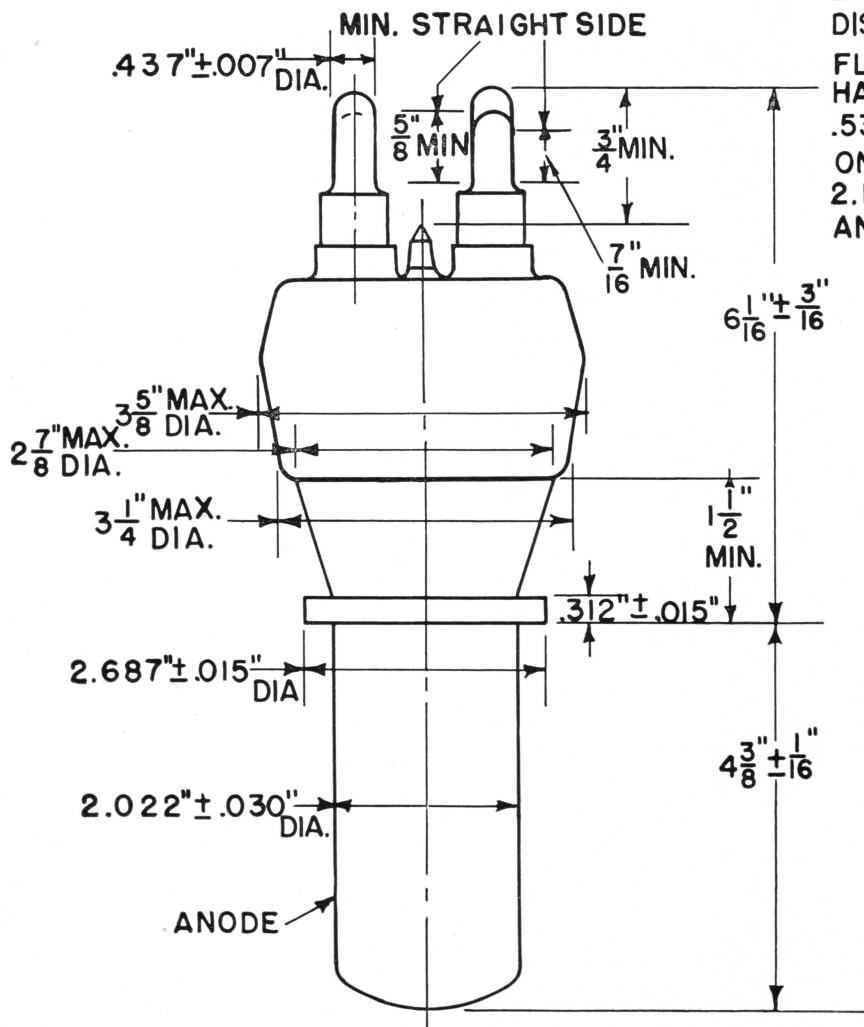
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3-5-48



NOTE:

THE TUBE BASE SHALL BE CAPABLE OF ENTERING TO A DISTANCE OF $\frac{5}{8}$ " IN A FLAT PLATE GAUGE HAVING FOUR HOLES $.536 \pm .001$ " DIA. ARRANGED ON A CIRCLE OF $2.125 \pm .001$ " DIA. AT ANGLES OF $90^\circ \pm 10'$



K-5344713

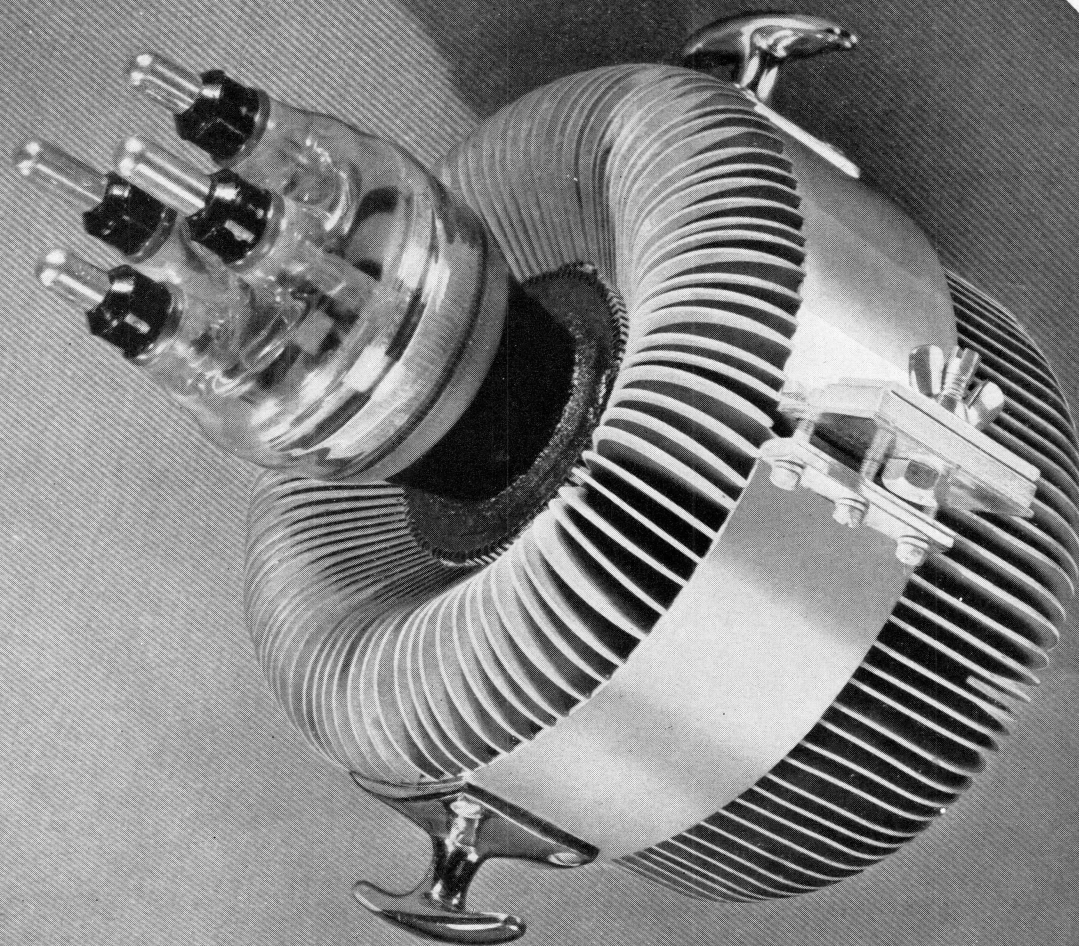
GL-889-A OUTLINE

3-16-45

ELECTRONIC COMPONENTS DIVISION

GENERAL  **ELECTRIC**

Schenectady 5, N. Y.



TRIODE

The GL-889R-A is a three-electrode power tube designed for use as a radio-frequency amplifier, oscillator, or Class B modulator. The plate is fitted with a special radiator and cooling is obtained by forced air. The design of the mount and terminal

connections minimizes lead inductance and makes the tube particularly suitable for high-frequency applications. The GL-889R-A can be operated at maximum ratings at frequencies as high as 40 megacycles and up to 100 megacycles at reduced ratings.

TECHNICAL INFORMATION

GENERAL

Electrical	Minimum	Bogey	Maximum
Filament voltage.....	—	11.0	11.5 volts
Filament current at bogey voltage.....	110	120	128 amperes
Filament starting current.....	—	—	180 amperes
Filament cold resistance.....	—	0.008	— ohm
Amplification factor, at $E_b = 1.0$ amp. $E_c = -100$ volts.....	17	21	25
Interelectrode capacitance			
Grid-plate.....	15.8	18.5	21.2 micromicrofarads
Grid-filament.....	19.2	23.3	27.4 micromicrofarads
Plate-filament.....	2.0	3.0	4.0 micromicrofarads


Electronic
TUBE

GENERAL  ELECTRIC

Supersedes ETX-181 dated 5-46

TECHNICAL INFORMATION (CONT'D)

Mechanical

Mounting position—vertical, anode down

Type of cooling—forced air

Maximum incoming air temperature 45 centigrade

Required air flow on anode

Plate dissipation—kilowatts 5.0 4.0 3.0

Air flow—cubic feet per minute 500 390 300

Static pressure—inches water 0.7 0.5 0.35

Required air flow to bulb* 15 cubic feet per minute

Maximum glass temperature 150 centigrade

Net weight, approximate 35 pounds

* Air to be directed at the top of tube from a 3-inch-diameter nozzle. Cooling air may be obtained by directing the required air flow at the top of the glass envelope through a 3-inch-diameter nozzle, or by deflecting air at the top of the bulb from the radiator-cooling-air stream.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

AUDIO-FREQUENCY POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum ratings, absolute values	CCS**		
D-c plate voltage	8500	maximum	volts
Maximum signal d-c plate current†	2	maximum	amperes
Maximum signal plate input†	12	maximum	kilowatts
Plate dissipation†	5	maximum	kilowatts
Typical operation	CCS*	CCS*	CCS*
Unless otherwise specified, values are for two tubes			
D-c plate voltage	5000	6000	7500 volts
D-c grid voltage	−180	−230	−300 volts
Peak a-f grid-to-grid voltage	1460	1680	1700 volts
Zero signal d-c plate current	0.4	0.4	0.4 amperes
Maximum signal d-c plate current	3.2	3.6	3.2 amperes
Effective load resistance, plate-to-plate	2520	3680	5000 ohms
Maximum signal driving power, approximate	170	180	150 watts
Maximum signal power output, approximate	8.8	12	15 kilowatts

† Averaged over any audio-frequency cycle of sine-wave form.

RADIO-FREQUENCY POWER AMPLIFIER—CLASS B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum ratings, absolute values	CCS**		
D-c plate voltage	8500	maximum	volts
D-c plate current	1.0	maximum	ampere
Plate input	7.5	maximum	kilowatts
Plate dissipation	5	maximum	kilowatts
Typical operation	CCS**	CCS**	
D-c plate voltage	6000	7500	volts
D-c grid voltage	−250	−300	volts
Peak r-f grid voltage	460	500	volts
D-c plate current	0.9	0.9	ampere
D-c grid current, approximate	0.003	0.005	ampere
Driving power, approximate|| . . . . .	95	80	watts
Power output, approximate	1.5	2	kilowatts

|| At crest of audio-frequency cycle with modulation factor of 1.0.

PLATE-MODULATED RADIO-FREQUENCY POWER AMPLIFIER—CLASS C TELEPHONY

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum ratings, absolute values	CCS**		
D-c plate voltage	6000	maximum	volts
D-c grid voltage	−1000	maximum	volts
D-c plate voltage	1.0	maximum	ampere
D-c grid current	0.25	maximum	ampere
Plate input	6	maximum	kilowatts
Plate dissipation	3	maximum	kilowatts

TECHNICAL INFORMATION (CONT'D)

Typical Operation.....	CCS**	CCS**	
D-c plate voltage.....	5000	6000	volts
D-c grid voltage.....	-800	-900	volts
Peak r-f grid voltage.....	1300	1420	volts
D-c plate current.....	0.9	1.0	ampere
D-c grid current, approximate.....	0.12	0.1	ampere
Driving power, approximate.....	155	140	watts
Power output, approximate.....	2.75	4	kilowatts

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

Key-down conditions per tube without amplitude modulation

Maximum ratings, absolute values.....	CCS**	
D-c plate voltage.....	8500	maximum volts
D-c grid voltage.....	-1000	maximum volts
D-c plate current.....	2	maximum amperes
D-c grid current.....	0.25	maximum ampere
Plate input.....	16	maximum kilowatts
Plate dissipation.....	5	maximum kilowatts

Typical operation.....	CCS**	CCS**	CCS**	
D-c plate voltage.....	5000	6000	7500	volts
D-c grid voltage.....	-500	-600	-800	volts
Peak r-f grid voltage.....	1200	1460	1830	volts
D-c plate current.....	1.5	1.8	2	amperes
D-c grid current, approximate.....	0.19	0.21	0.24	amperes
Driving power, approximate.....	220	290	400	watts
Power output, approximate.....	5	7	10	kilowatts

Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of the carrier conditions.

**CCS—Continuous Commercial Service.

APPLICATION NOTES

* The GL-889R-A can be operated at maximum ratings in all classes of service at frequencies as high as 40 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under TECHNICAL

INFORMATION.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 100 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

Frequency.....	40	65	100	megacycles
Percentage of maximum rated plate voltage and plate input				
Class B.....	100	85	72	per cent
Class C plate modulated.....	100	78	60	per cent
Class C unmodulated—maximum plate voltage.....	100	87	65	per cent
Class C unmodulated—maximum plate input.....	100	73	50	per cent

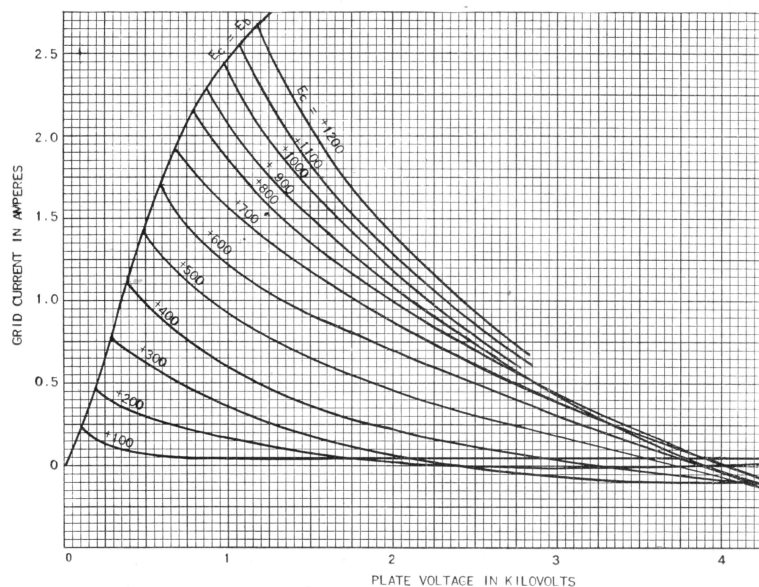
GL-889R-A

ETX-181A

PAGE 4

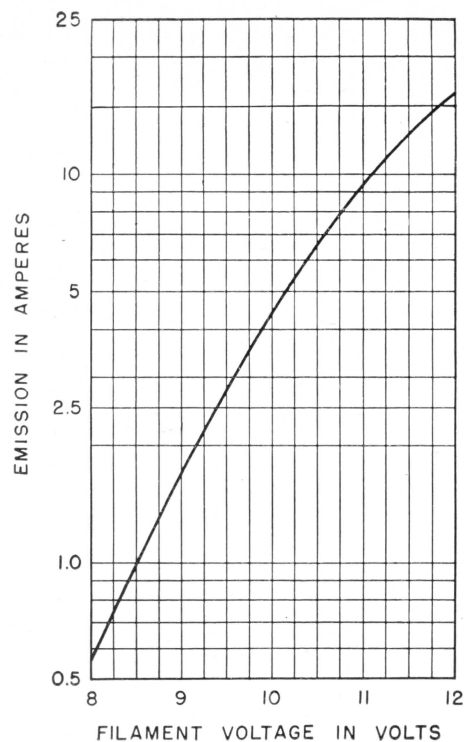
4-49

GL-889R-A
TYPICAL GRID-PLATE TRANSFER CHARACTERISTIC
 $E = 11_f$ VOLTS A-C



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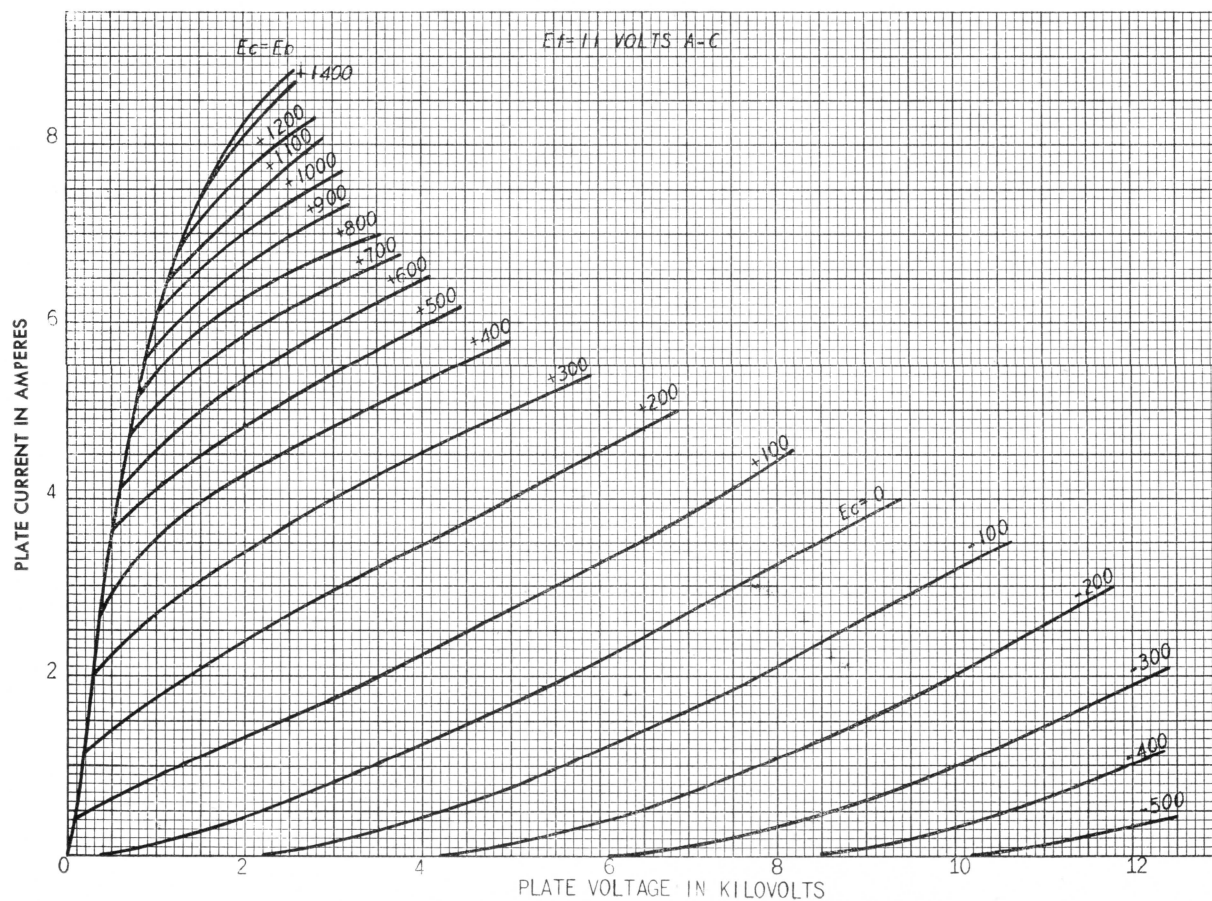
GL-889R-A EMISSION CHARACTERISTICS



3-5-48 K-8074633

12-10-45

GL-889R-A
AVERAGE PLATE CHARACTERISTIC

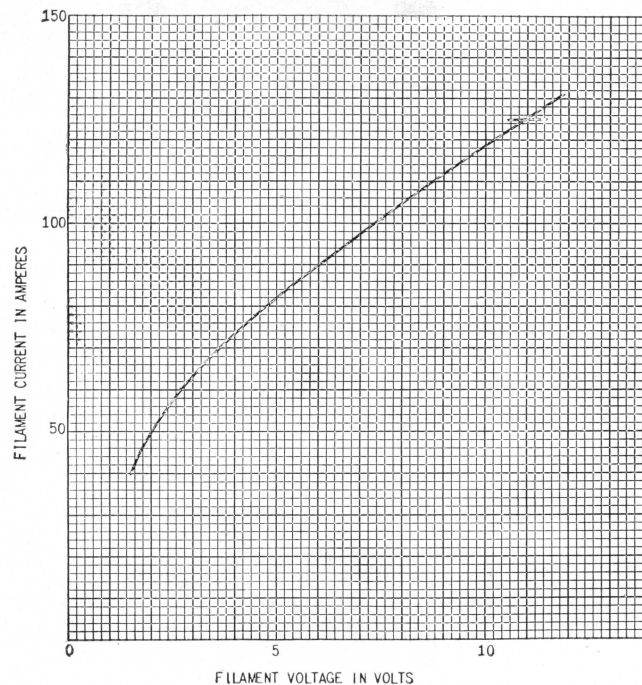


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3-5-48

GL-889R-A AVERAGE FILAMENT CHARACTERISTICS

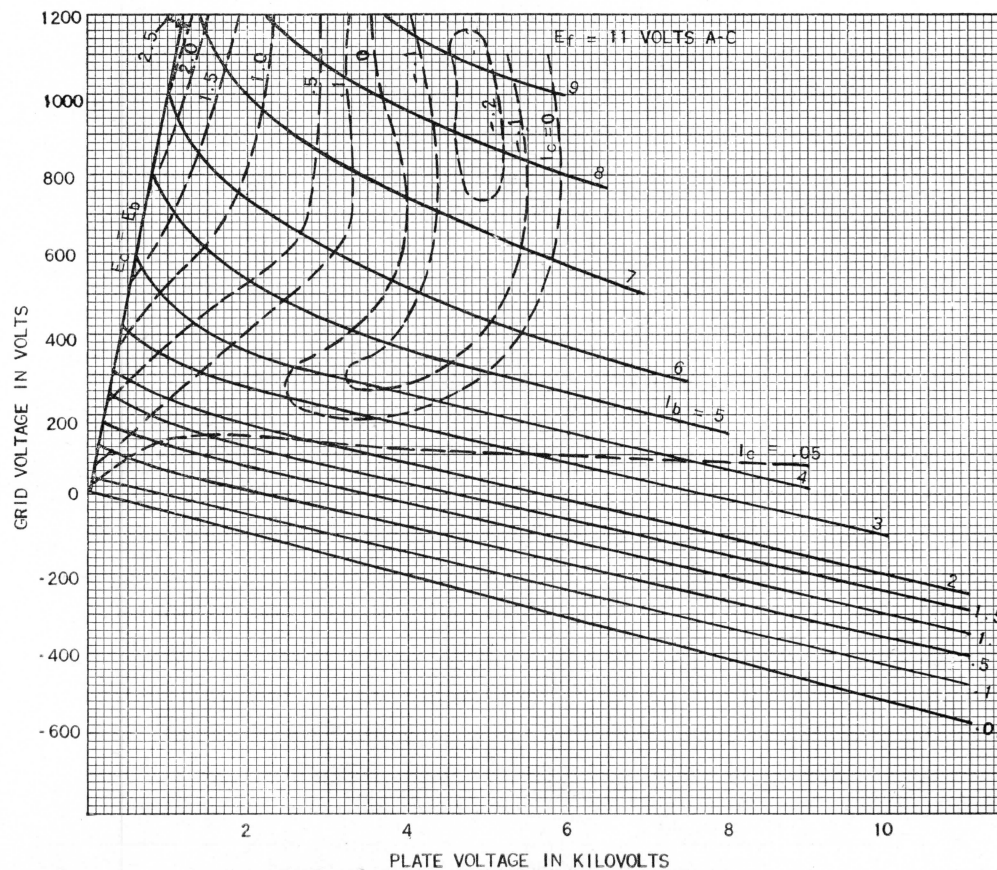
COLD RESISTANCE = 0.0003 OHM



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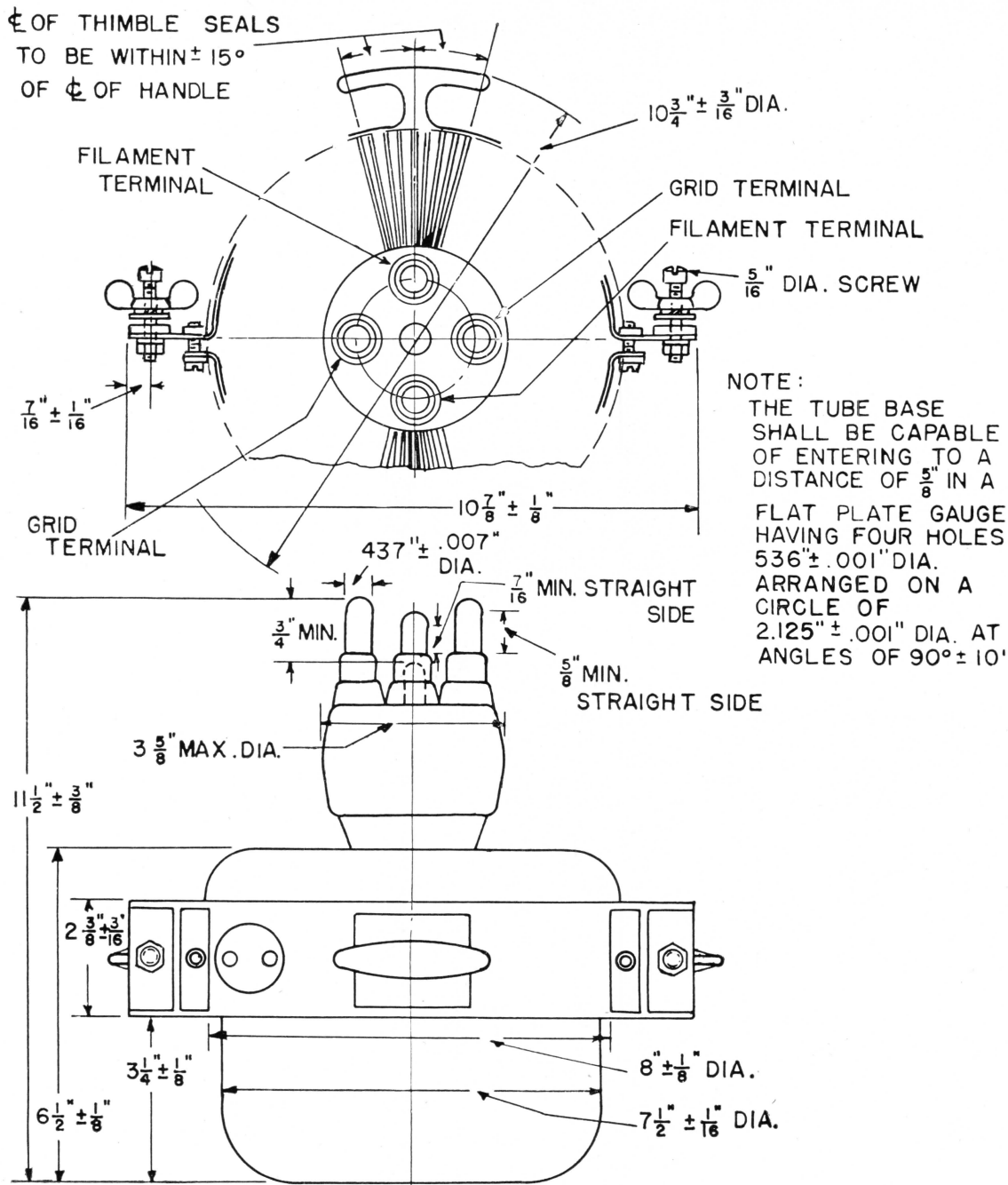
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GL-889R-A CHARACTERISTIC



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GL-889R-A, OUTLINE

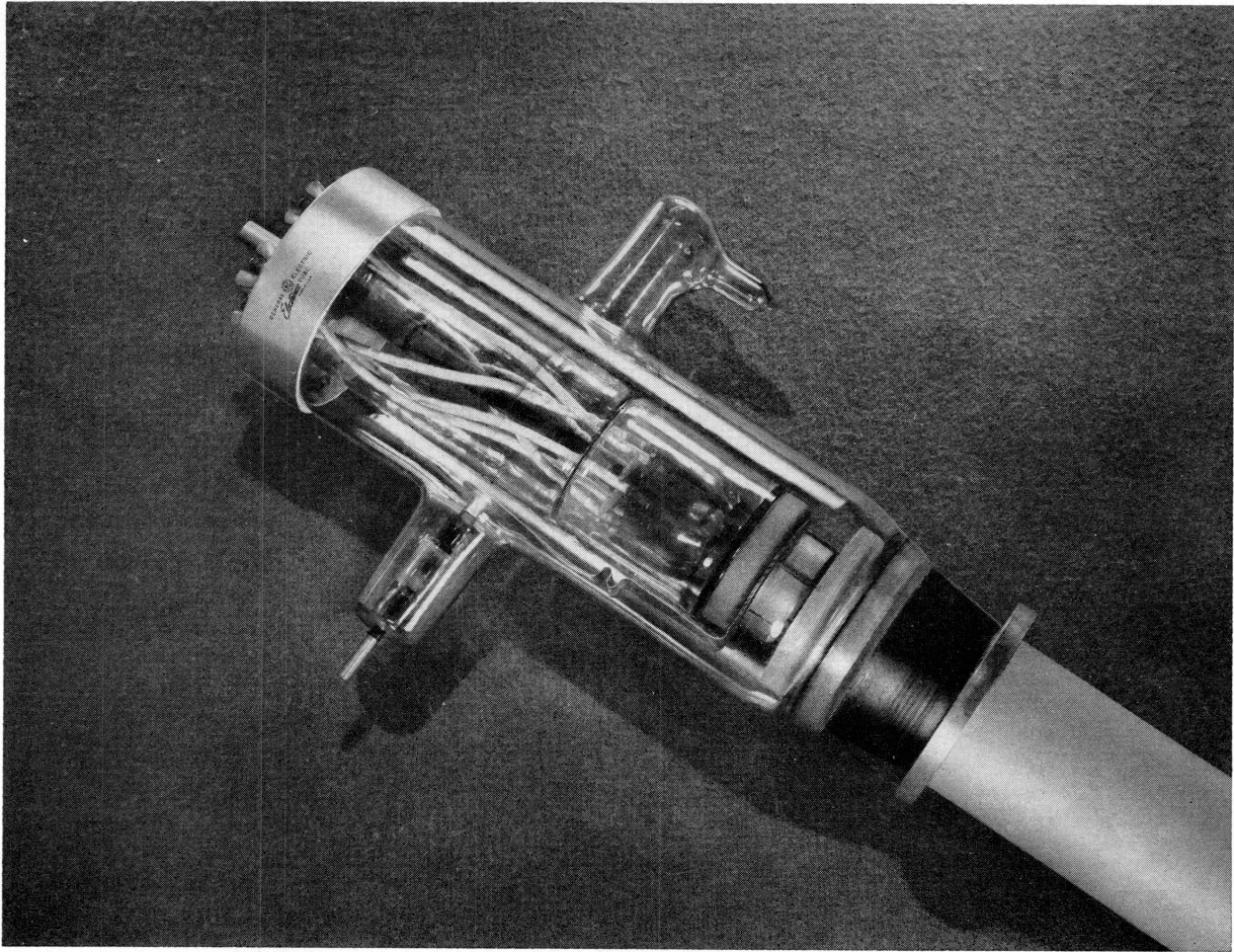
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3-16-45

ELECTRONIC COMPONENTS DIVISION

GENERAL  **ELECTRIC**

Schenectady 5, N. Y.



TRIODE

The GL-898-A is a three-electrode power tube designed for use as a radio-frequency amplifier, oscillator, or Class B modulator. The filament consists of three sections and can be operated on

d-c, single-phase, or three-phase filament excitation. The plate is capable of dissipating 50 to 100 kilowatts.

TECHNICAL INFORMATION

GENERAL

Number of Electrodes.....3

Electrical

Cathode—Filamentary

Filament Voltage, per section.....33 Volts

Filament Current, per section.....70 Amperes

Average Characteristics, $E_b = 20.5$ kv, $I_b = 3.0$ amperes, $E_r = 33$ volts

Grid Voltage.....-100 Volts

Amplification Factor.....45

Grid-Plate Transconductance, $I_b = 3.0$ amperes.....17,500 Micromhos

Direct Interelectrode Capacitances

Grid to Plate.....62 μmf

Grid to Filament.....52 μmf

Plate to Filament.....4.2 μmf

Frequency for Maximum Ratings.....1.6 Megacycles

GENERAL  ELECTRIC

§Supersedes pages 1 and 2 dated 5-46;

TECHNICAL INFORMATION (CONT'D)

Mechanical

Mounting Position—Vertical, anode down		
Net Weight, approximate	30	Pounds
Shipping Weight, appropriate	175	Pounds

Thermal

Type of Cooling—Water and Forced Air		
Maximum Outlet Temperature	70	C
Water Flow	15 to 25	Gallons per Minute
Jacket Type	7651927	
Maximum Incoming Air Temperature	50	C
Flow		
To Bulb	15	Cubic Feet per Minute
To Stem	3	Cubic Feet per Minute
Gasket	Cat. No. 5182028P1	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B AUDIO-FREQUENCY POWER AMPLIFIER (TWO TUBES)	Typical Operation	Maximum Ratings
DC Plate Voltage	12,000	15,000 Volts
Maximum Signal Plate Current*, per tube		7.5 Amperes
DC Maximum Signal Plate Input*, per tube		100 Kilowatts
Plate Dissipation*, per tube		50 Kilowatts
DC Grid Voltage	-100	Volts
Peak AF Grid Input Voltage	2200	Volts
Zero Signal Plate Current	2	Amperes
Maximum Signal Plate Current	13	Amperes
Maximum Signal Driving Power, approximate	6	Kilowatts
Effective Load, plate-to-plate	2000	Ohms
Maximum Signal Plate Power Output, approximate	90	Kilowatts

CLASS B RADIO-FREQUENCY POWER AMPLIFIER

Carrier Conditions per Tube for Use with a Maximum Modulation Factor of 1.0

DC Plate Voltage	12,000	15,000	18,000	20,000	Volts
DC Grid Voltage	-100	-175	-250		Volts
⊕ DC Plate Current	2.8	3.5	4.2	5	Amperes
Plate Input				100	Kilowatts
Plate Dissipation				75	Kilowatts
Peak RF Grid Input Voltage	525	650	775		Volts
Driving Power†, approximate	0.5	0.75	1.1		Kilowatts
Plate Power Output, approximate	11	17.5	25		Kilowatts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—PLATE-MODULATED

Carrier Conditions per Tube for Use with a Maximum Modulation Factor of 1.0

DC Plate Voltage	12,000	12,000	Volts
DC Grid Voltage	-800	-3000	Volts
DC Plate Current	5	5	Amperes
DC Grid Current, approximate	1	1.25	Amperes
Plate Input		60	Kilowatts
Plate Dissipation		50	Kilowatts
Peak RF Grid Input Voltage	2000		Volts
Driving Power	2		Kilowatts
Plate Power Output	45		Kilowatts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Key-Down Conditions per Tube Without Modulation

DC Plate Voltage	12,000	15,000	18,000	20,000	Volts
DC Grid Voltage	-800	-900	-1000	-3000	Volts
DC Plate Current	6.25	7.5	8.33	10	Amperes
DC Grid Current, approximate	0.8	0.85	0.9	1	Amperes
Plate Input				200	Kilowatts
Plate Dissipation				100	Kilowatts
Peak RF Grid Input Voltage, approximate	2050	2300	2550		Volts
Driving Power, approximate	1.6	2	2.4		Kilowatts
Plate Power Output, approximate	50	75	100		Kilowatts

* Averaged over any audio-frequency cycle.

† At crest of audio-frequency cycle.

Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

⊕ Denotes a change.

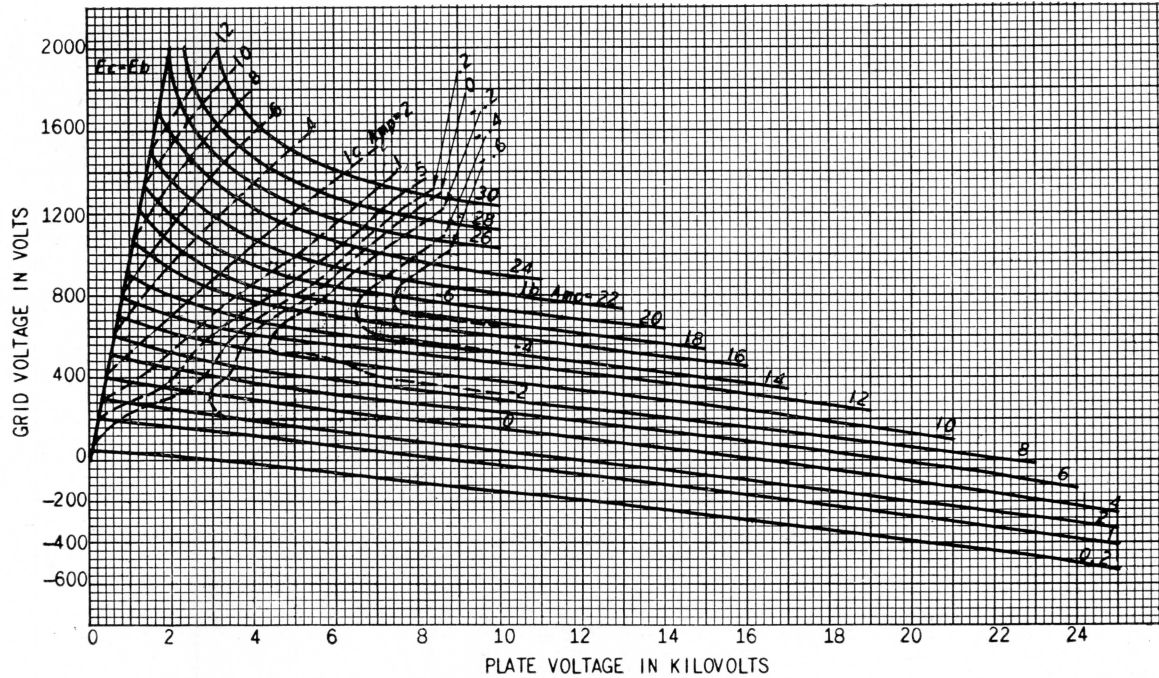
APPLICATION NOTES

Plate series protective resistors (see paragraph describing plate circuit under Installation in the Instructions)

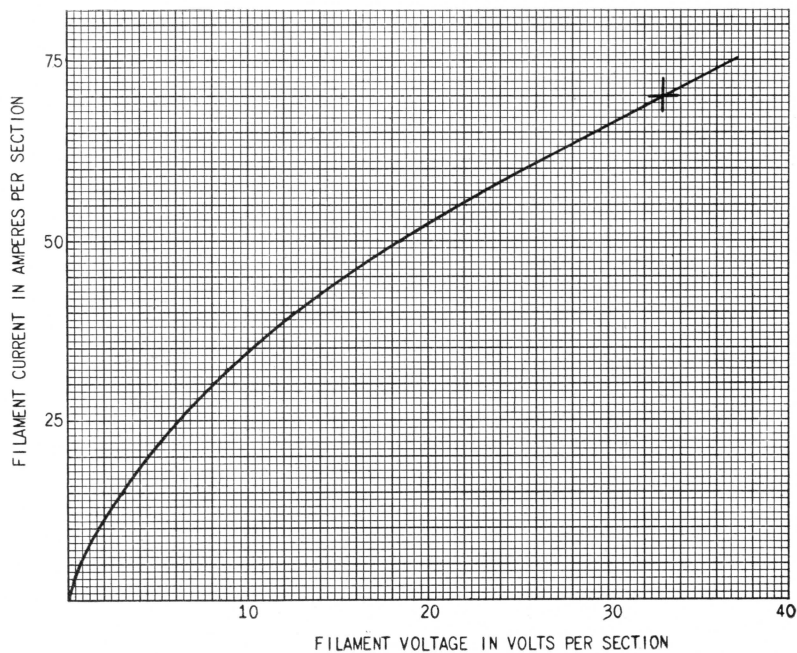
Series resistor.....	10	20	40	50 ohms
Maximum power output of rectifier.....	100	250	640	1600 kilowatts

GL-898-A CHARACTERISTICS

($E_f = 33$ VOLTS A-C)



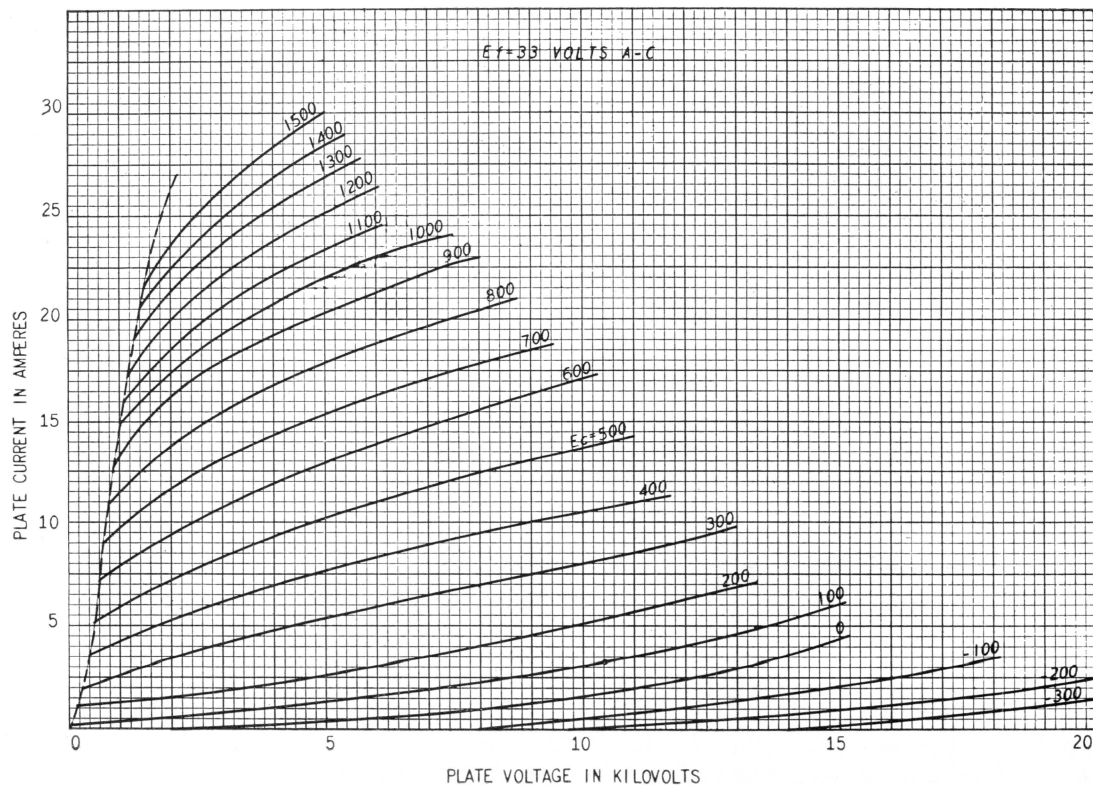
GL-898-A FILAMENT CHARACTERISTIC
(COLD RESISTANCE OF EACH SECTION OF FILAMENT=0.042 OHMS)



K-6966422

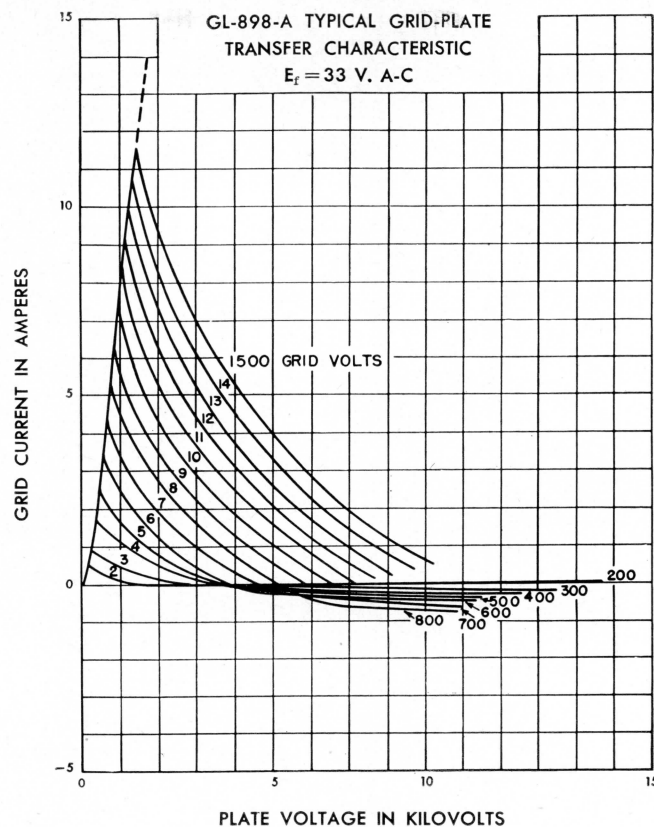
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GL-898-A
AVERAGE PLATE CHARACTERISTICS



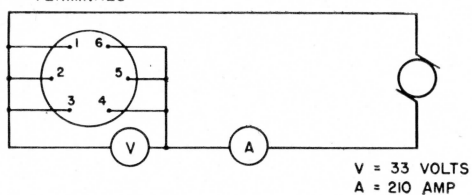
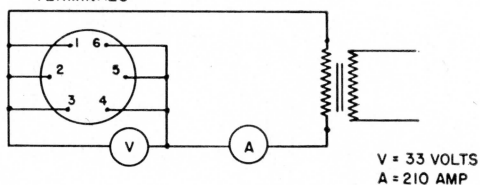
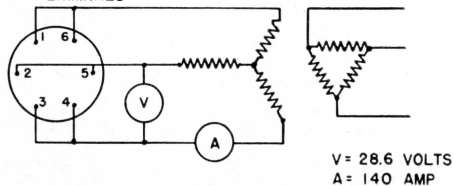
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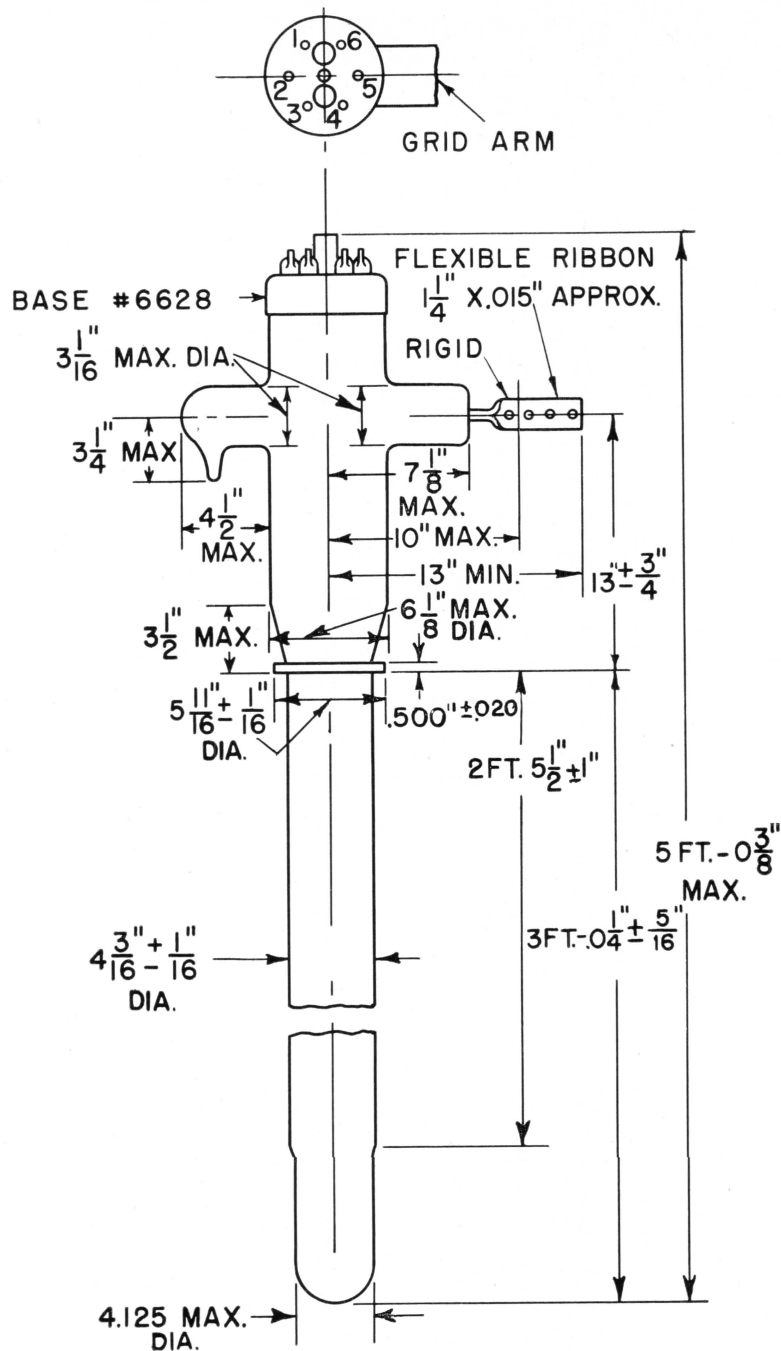
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FILAMENT BASE
TERMINALSFILAMENT BASE
TERMINALSFILAMENT BASE
TERMINALS

FILAMENT CONNECTIONS AND EXCITATION CIRCUITS

K-9033994

1-9-46



GL-898-A OUTLINE

K-5185285

1-9-46



TRIODE

The GL-5513 is a three-electrode tube designed for use as a grounded-grid Class B radio-frequency amplifier and Class C amplifier and oscillator. The anode is forced-air cooled and is capable of dissipat-

ing 1200 watts. The cathode is a thoriated-tungsten filament. Maximum ratings apply up to 220 megacycles.

TECHNICAL INFORMATION

GENERAL

Electrical	Minimum	Bogey	Maximum
Filament Voltage.....	6.0	6.3	6.6 Volts
Filament Current at Bogey Voltage.....	—	⊕30	— Amperes
Filament Starting Current.....	—	—	□55 Amperes
Filament Cold Resistance.....	—	□0.026	— Ohms
Filament Heating Time.....	□30	—	— Seconds
Amplification Factor, $I_b = 0.4$ amperes, $E_c = +10$ volts.....	—	⊕49	—
Peak Cathode Current*.....	—	—	□5 Amperes
Direct-Interelectrode Capacitances			
Grid-Plate.....	—	⊕10.5	— $\mu\mu\text{f}$
Grid-Filament.....	—	⊕14.4	— $\mu\mu\text{f}$
Plate-Filament**.....	—	⊕0.09	— $\mu\mu\text{f}$

*Represents maximum useable cathode current (plate current plus current to each grid) for any condition of operation.

**Measured with a 10-inch outside diameter metal disk placed on the grid seal.


Electronic
TUBE

GENERAL  ELECTRIC

Supersedes ETX-220A dated 4-49

TECHNICAL INFORMATION (CONT'D)

Mechanical

Mounting Position—Vertical, Anode Down

Air Flow

Through Radiator

Plate Dissipation.....	700	1000	1200 Max	Watts
Air Flow.....	40	47	55 Min	Cubic Feet per Minute
Static Pressure.....	1.0	1.3	1.5	Inches Water
Filament—Terminal Seals.....			5 Min	Cubic Feet per Minute
Incoming Air Temperature.....			45 Max	C
Radiator Hub Temperature.....			□180 Max	C
Glass Temperature at Any Point.....			150 Max	C
Net Weight, approximate.....			3 3/4	Pounds

Forced-air cooling to be maintained through radiator and on filament seals for one minute minimum after removal of all voltages. Forced-air cooling to be applied to filament terminal seals and through radiator before any voltages are applied.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

RADIO-FREQUENCY POWER AMPLIFIER—CLASS B

Carrier Conditions per Tube for Use with a Maximum Modulation Factor of 1.0

Maximum Ratings, Absolute Values

DC Plate Voltage.....	4000 Max	Volts
DC Plate Current.....	±0.83 Max	Amperes
Plate Input.....	1800 Max	Watts
Plate Dissipation.....	1200 Max	Watts

Typical Operation	Grounded-Cathode Circuit		Grounded-Grid Circuit		
	□	±	□	±	
DC Plate Voltage.....	2500	3000	2500	3000	Volts
DC Grid Voltage.....	−20	±−25	−20	±−25	Volts
Peak RF Grid Voltage.....	95	±115	95	±115	Volts
Peak RF Plate Voltage.....	950	□1200	950	□1200	Volts
DC Plate Current.....	□0.375	±0.470	□0.375	±0.470	Amperes
DC Grid Current, approximate.....	□0.040	±0.042	□0.040	±0.042	Amperes
Driving Power, approximate†.....	□25	±34	—	—	Watts
Carrier.....	—	—	□31.5	□47	Watts
Crest†.....	—	—	□132	□187	Watts
Power Output.....	□277	±437	□305‡	±480‡	Watts

RADIO-FREQUENCY AMPLIFIER—CLASS B TELEVISION SERVICE

Synchronizing-Level Conditions per Tube unless Otherwise Specified

Maximum Ratings, Absolute Values

DC Plate Voltage.....	3000 Max	Volts
DC Plate Current.....	1.2 Max	Amperes
Plate Input.....	3300 Max	Watts
Plate Dissipation.....	1200 Max	Watts

Typical Operation—Grounded-Grid Circuit up to 220 Megacycles

Bandwidth 5 Megacycles

DC Plate Voltage.....	±2000	Volts
DC Grid Voltage.....	±−20	Volts
Peak RF Driving Voltage		
Synchronizing Level.....	□240	Volts
Pedestal Level.....	□180	Volts
Peak RF Plate Voltage		
Synchronizing Level.....	□1260	Volts
Pedestal Level.....	□955	Volts
DC Plate Current		
Synchronizing Level.....	□0.967	Amperes
Pedestal Level.....	□0.680	Amperes

TECHNICAL INFORMATION (CONT'D)

DC Grid Current		
Synchronizing Level.....	☐ 0.180	Amperes
Pedestal Level.....	☐ 0.105	Amperes
Driving Power at Tube, approximate		
Synchronizing Level.....	☐ 223	Watts
Pedestal Level.....	☐ 183	Watts
Power Output, approximate		
Synchronizing Level†.....	☐ 1125	Watts
Pedestal Level‡.....	☐ 662	Watts

PLATE-MODULATED RADIO-FREQUENCY POWER AMPLIFIER—CLASS C TELEPHONY

Carrier Conditions per Tube for use with a Maximum Modulation Factor of 1.0

Maximum Ratings, Absolute Values

DC Plate Voltage.....	⊕3200 Max	Volts
DC Grid Voltage.....	⊕ - 250 Max	Volts
DC Plate Current.....	⊕0.83 Max	Amperes
DC Grid Current.....	⊕0.250 Max	Amperes
Plate Input.....	2100 Max	Watts
Plate Dissipation.....	800 Max	Watts

Typical Operation

Grounded-Cathode
CircuitGrounded-Grid
Circuit

DC Plate Voltage.....	⊕2800	Volts
DC Grid Voltage.....	⊕ - 150	Volts
Peak RF Grid Voltage.....	⊕332	Volts
Peak RF Plate Voltage.....	☐ 2100	Volts
DC Plate Current.....	⊕0.60	Amperes
DC Grid Current, approximate.....	⊕0.104	Amperes
Driving Power, approximate.....	⊕202‡	Watts
Power Output, approximate.....	⊕1250 π	Watts

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

Key-Down Conditions per Tube Without Amplitude Modulation§

Maximum Ratings, Absolute Values

DC Plate Voltage.....	4000 Max	Volts
DC Grid-No. 1 Voltage.....	⊕ - 250 Max	Volts
DC Plate Current.....	1.0 Max	Amperes
DC Grid Current.....	⊕0.250 Max	Amperes
Plate Input.....	3600 Max	Watts
Plate Dissipation.....	1200 Max	Watts

Typical Operation

Grounded-Cathode
CircuitGrounded-Grid
Circuit

DC Plate Voltage.....	3000	3750	3000	3750	Volts
DC Grid-No. 1 Voltage.....	⊕ - 100	⊕ - 150	⊕ - 100	⊕ - 150	Volts
Peak RF Grid-No. 1 Voltage.....	⊕245	⊕250	⊕245	⊕250	Volts
Peak RF Plate Voltage.....	☐ 2140	☐ 2950	☐ 2140	☐ 2950	Volts
DC Plate Current.....	⊕0.98	⊕0.94	⊕0.98	⊕0.94	Amperes
DC Grid-No. 1 Current, approximate.....	⊕0.164	⊕0.159	⊕0.164	⊕0.159	Amperes
Driving Power, approximate.....	⊕56	⊕64	⊕340	⊕377	Watts
Power Output, approximate.....	⊕1760	⊕2370	⊕2040	⊕2690	Watts

† At crest of audio-frequency cycle with modulation factor of 1.0.

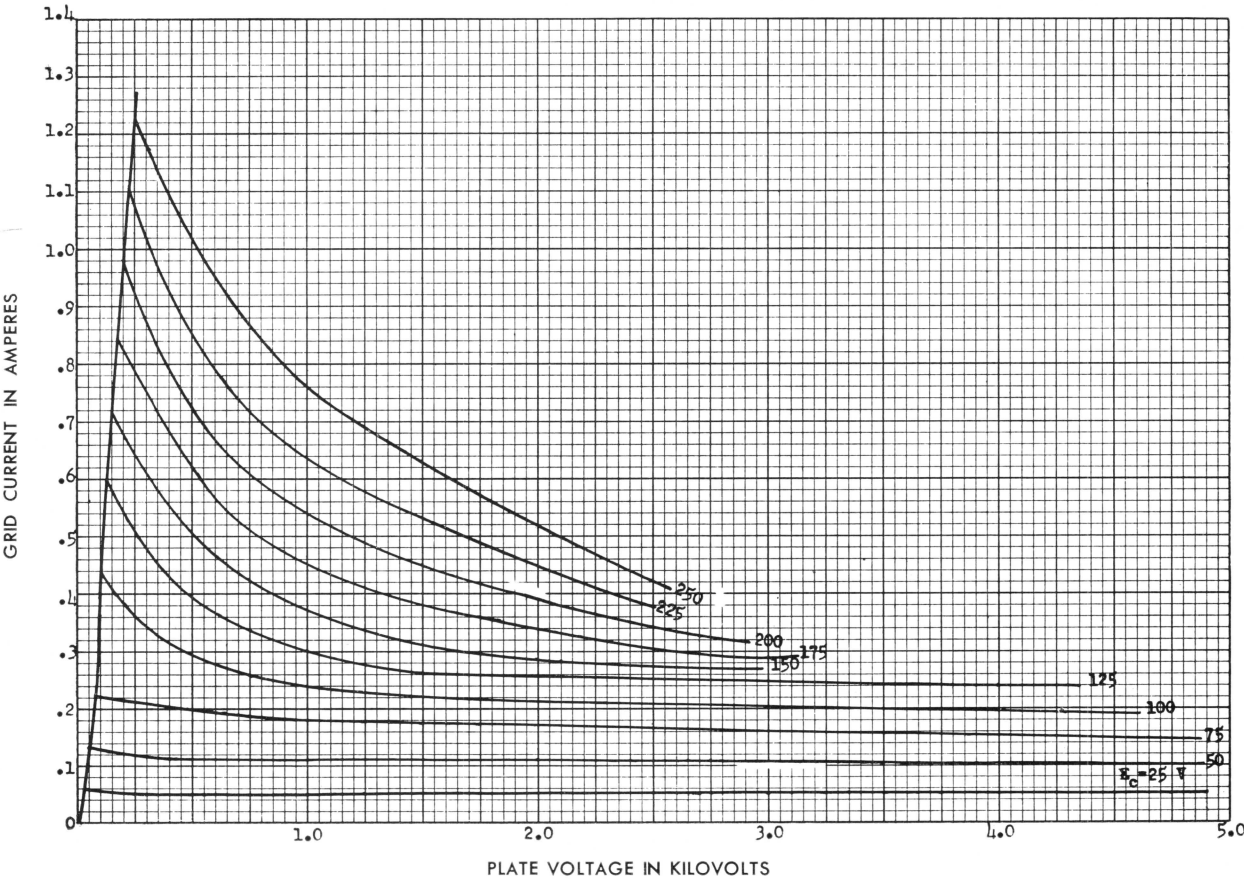
‡ Includes power transferred from driver stage.

π The carrier of the driver modulated 100 percent.

§ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 percent of the carrier conditions.

⊕ Denotes change.

☐ Denotes addition.



GRID CHARACTERISTICS
 $E_f = 6.3$ VOLTS

K-69087-72A639

2-11-54

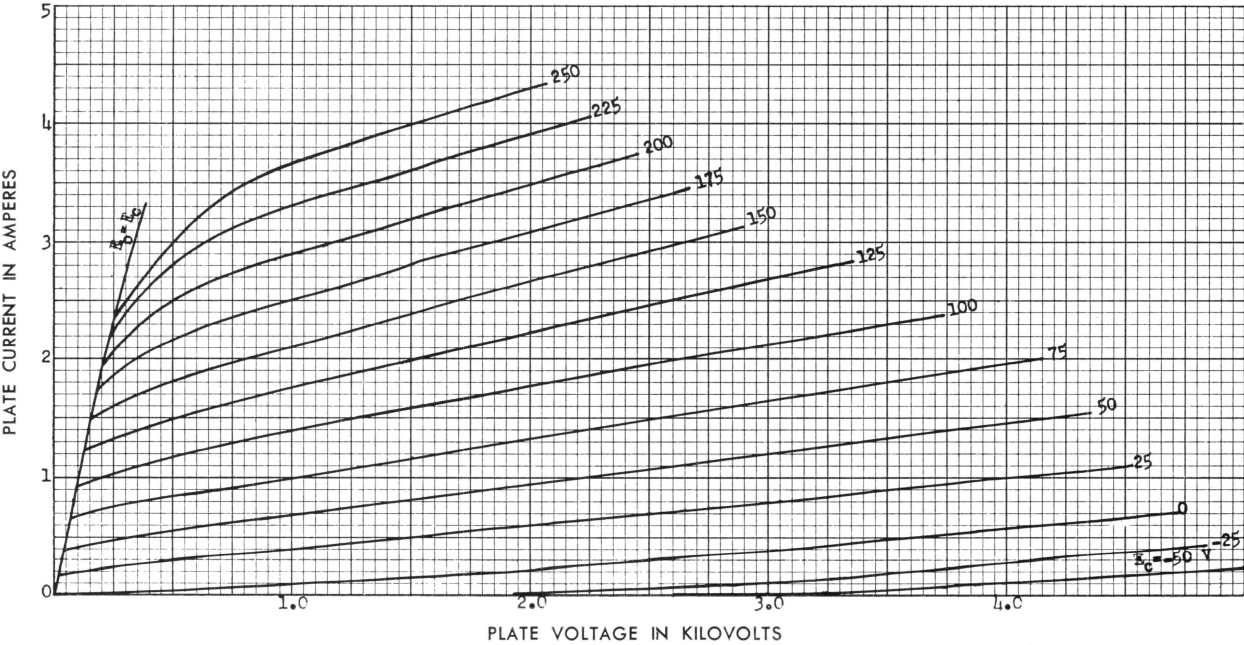
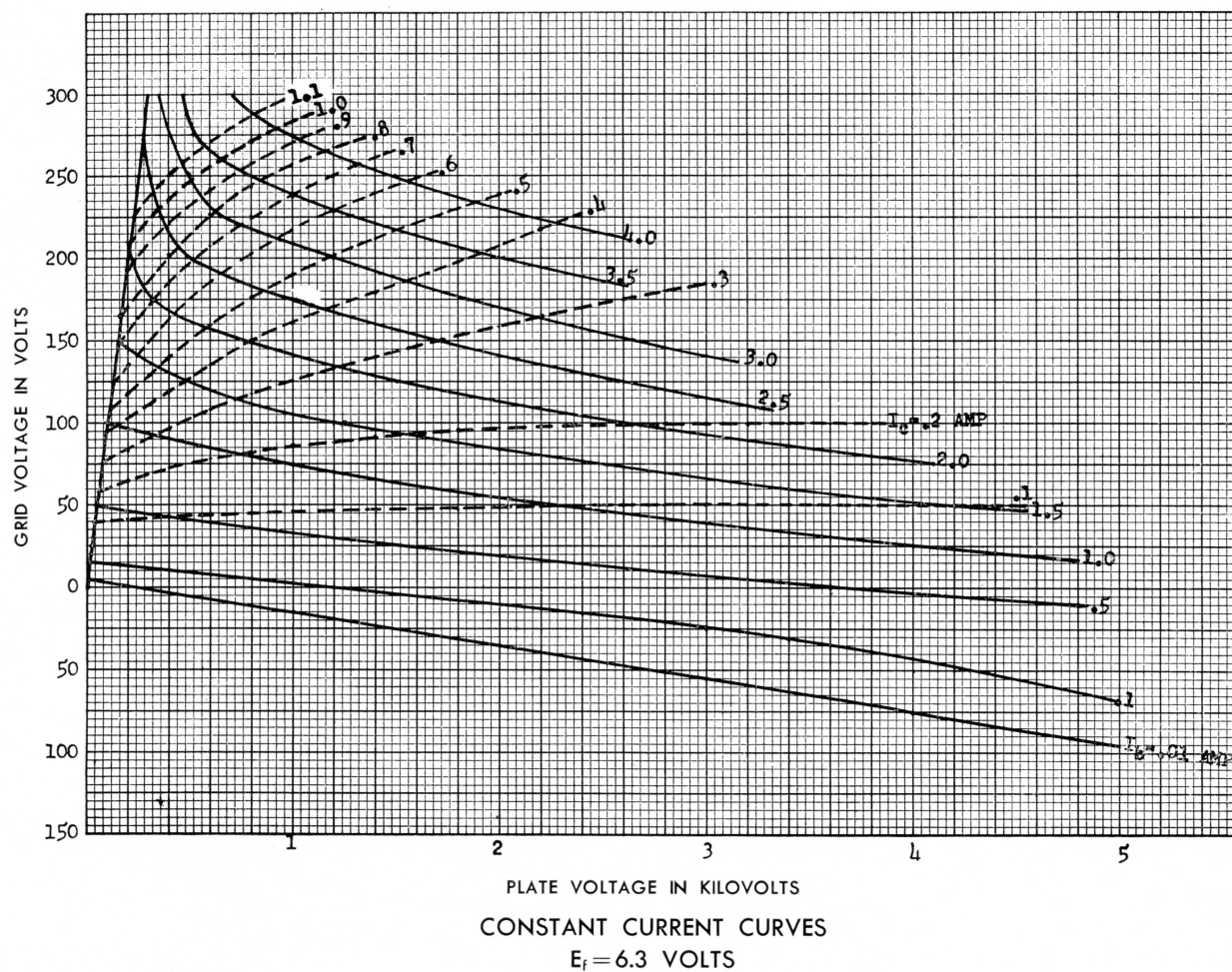


PLATE CHARACTERISTICS
 $E_f = 6.3$ VOLTS

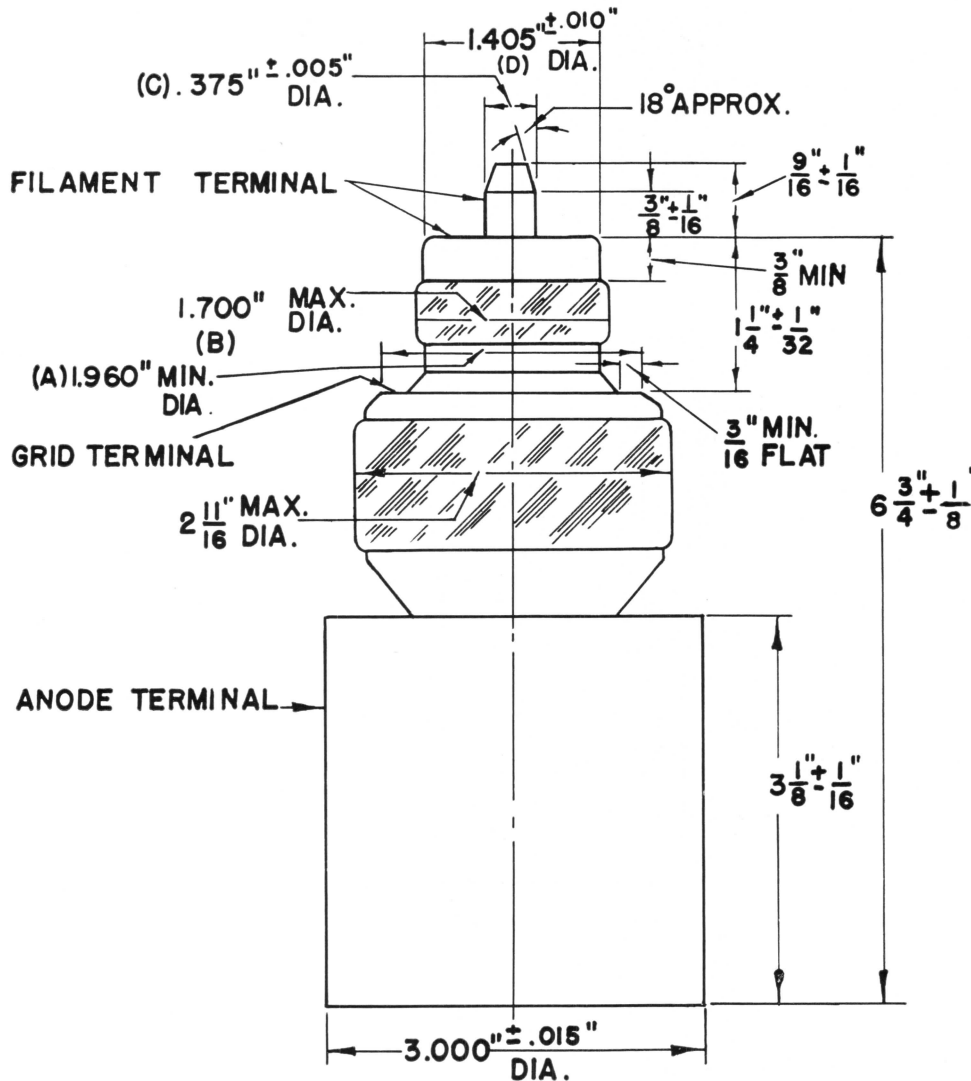
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K-69087-72A638

2-11-54



DIMENSIONS "A" AND "B" ARE MAXIMUM AND MINIMUM DIMENSIONS OF ANY POINT ON THE CIRCUMFERENCE OF THE REFERENCED PART OF THE TUBE. THESE CIRCUMFERENCES SHALL BE CONCENTRIC WITH A ϕ ESTABLISHED THRU THE CENTER OF THE BOTTOM OF THE RADIATOR AND CENTER OF THE "D" DIAMETER. DIMENSION "C" TO BE HELD TO A MAXIMUM ECCENTRICITY OF .020" WITH THIS ϕ . DIMENSION "D" TO BE HELD TO A MAXIMUM ECCENTRICITY OF .050" WITH RESPECT TO CENTER LINE ESTABLISHED BY THE RADIATOR ALONE.

N-21210AZ

2-19-47

TUBE DEPARTMENT

GENERAL  **ELECTRIC**

Schenectady 5, N. Y.



TRIODE

The GL-5518 is a three-electrode transmitting tube designed for use as a Class C radio-frequency amplifier. This tube is particularly well adapted to use in a grounded-grid circuit. The anode is forced-

air-cooled, and capable of dissipating 4000 watts. The cathode is a pure-tungsten filament. Maximum ratings apply up to 110 megacycles.

TECHNICAL INFORMATION

GENERAL

Electrical	Minimum	Bogey	Maximum
Filament voltage.....	—	6.3	6.6 volts
Filament current at bogey voltage.....	227	235	243 amperes
Filament starting current.....	—	—	355 amperes
Filament cold resistance.....	—	0.0023	— ohm
Amplification factor, $I_b = 1.0$ amp, $E_c = 50$ v.....	17	21	25
Interelectrode capacitances			
Grid-plate.....	16	18.5	21 uuf
Grid-filament.....	26	29	32 uuf
Plate-filament†.....	—	—	0.6 uuf
Mechanical			
Mounting position—Vertical, anode down			
Type of cooling—Forced air			
Maximum incoming air temperature.....	—	—	45 C

GENERAL  ELECTRIC

Supersedes ETX-221 dated 5-47


Electronic
TUBE

TECHNICAL INFORMATION (CONT'D)

Required air flow on anode*

Plate dissipation—per cent of rating	100	80	60
Air flow—cubic feet per minute	350	250	200
Pressure—inches water	1.85	1.15	0.80

Required air flow on filament and grid seals

Around circumference of filament seals	15	cfm
Around circumference of grid seal	55	cfm
Maximum glass temperature	175	C
Net weight, approximate	17	pounds

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

RADIO-FREQUENCY POWER AMPLIFIER—CLASS C TELEGRAPHY

Key-down conditions per tube without amplitude modulation¶

Maximum ratings, absolute values	CCS†
D-c plate voltage	7,000 max volts
D-c grid voltage	—850 max volts
D-c plate current	1.8 max amperes
D-c grid current	0.25 max ampere
Plate input	12 max kilowatts
Plate dissipation	4 max kilowatts
Typical operation, grounded-filament circuit	CCS†
D-c plate voltage	6,600 volts
D-c grid voltage	—520 volts
Peak r-f grid voltage	940 volts
D-c plate current	1.3 amperes
D-c grid current, approximate	0.20 ampere
Driving power, approximate	180 watts
Power output, approximate	6.5 kilowatts
Typical operation, grounded-grid circuit	
Same values as for grounded-filament circuit with the following exceptions:	
Driving power, approximate	CCS† 1,220 watts
Power output #, approximate	7.5 kilowatts

† Measured with a 12-inch outer diameter and 3-inch inner diameter flat shield on grid terminal.

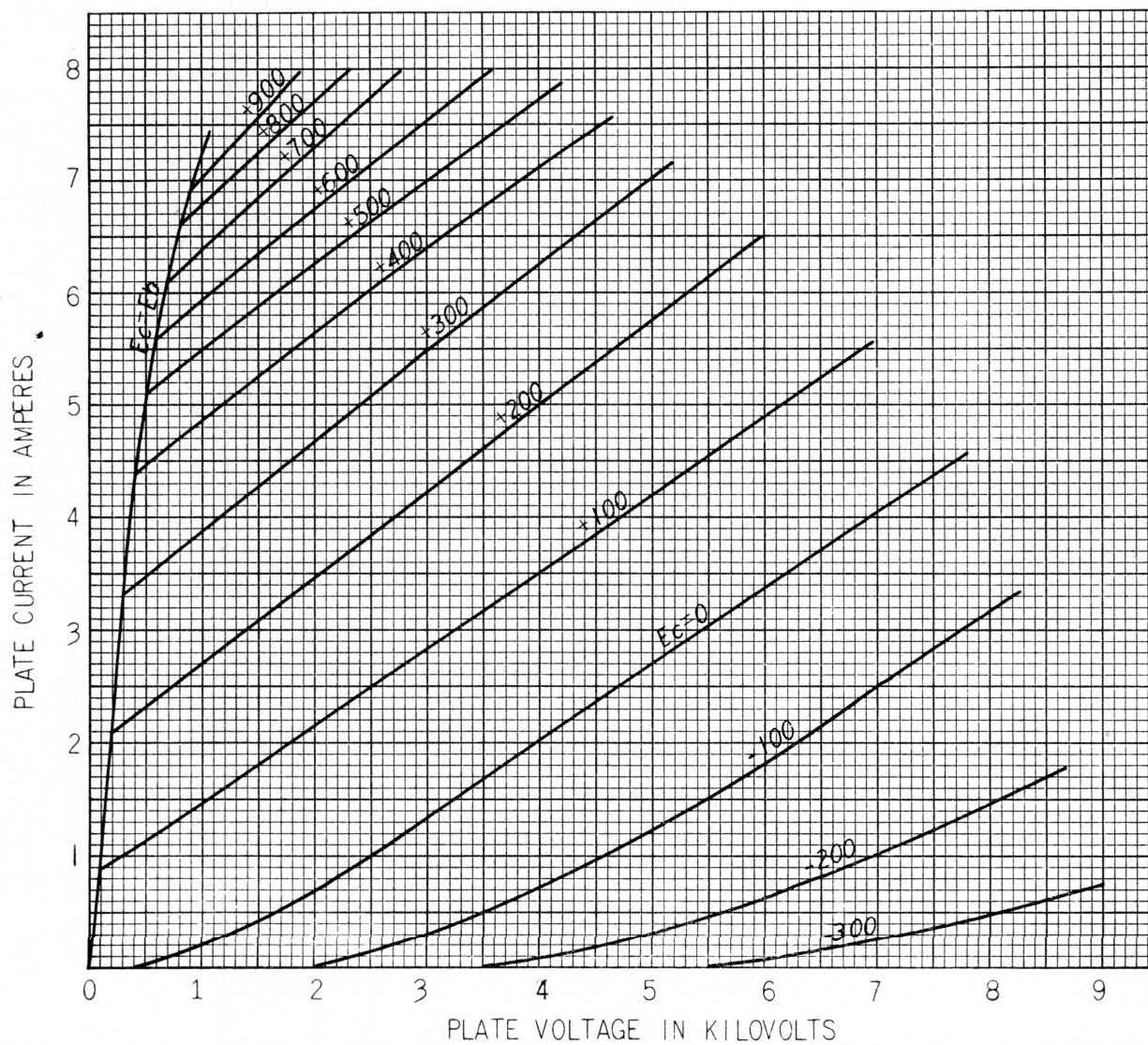
* Direction of air flow must be downward through radiator.

¶ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of the carrier conditions.

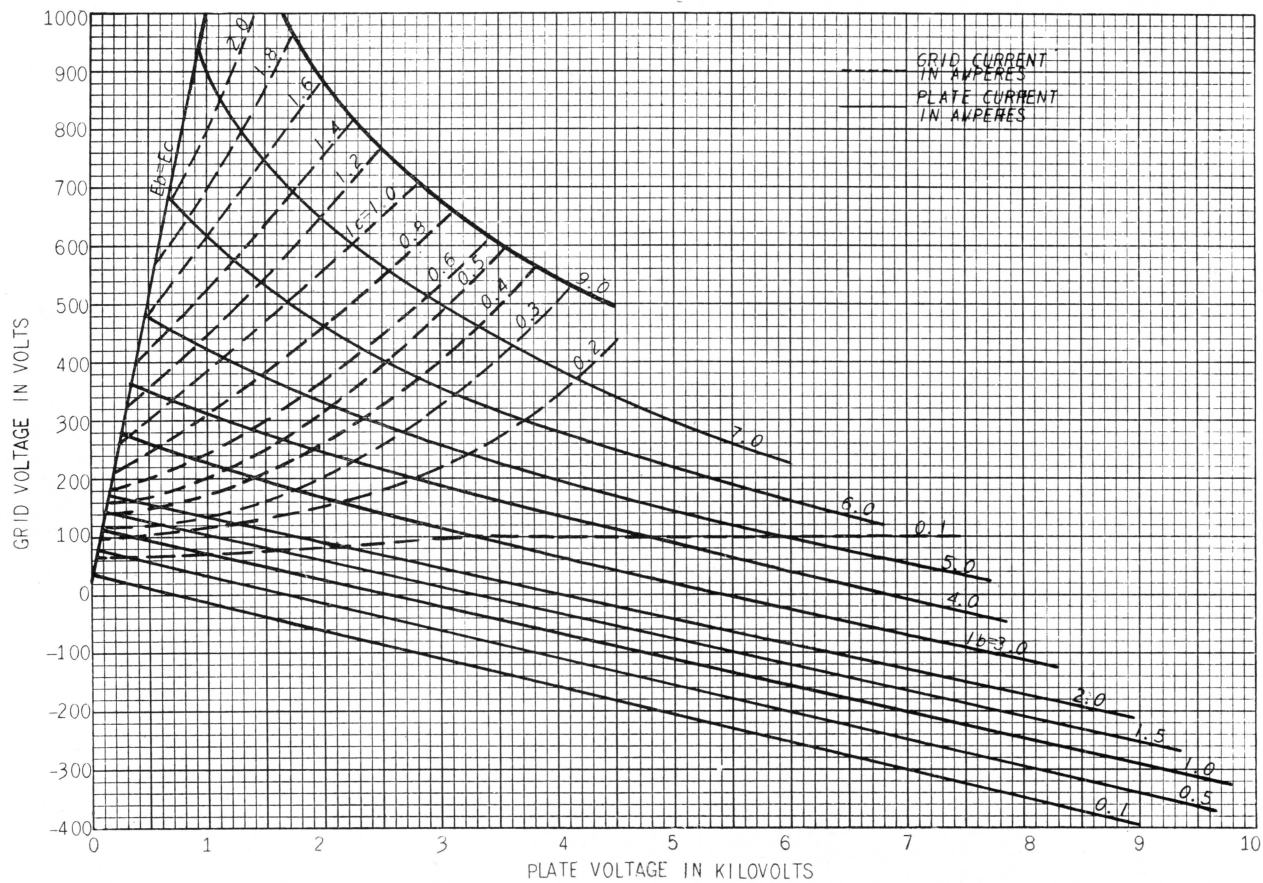
† Continuous Commercial Service.

This value includes power transferred from driver to output.

GL-5518
AVERAGE PLATE CHARACTERISTICS
 $E_i = 6.3$ VOLTS



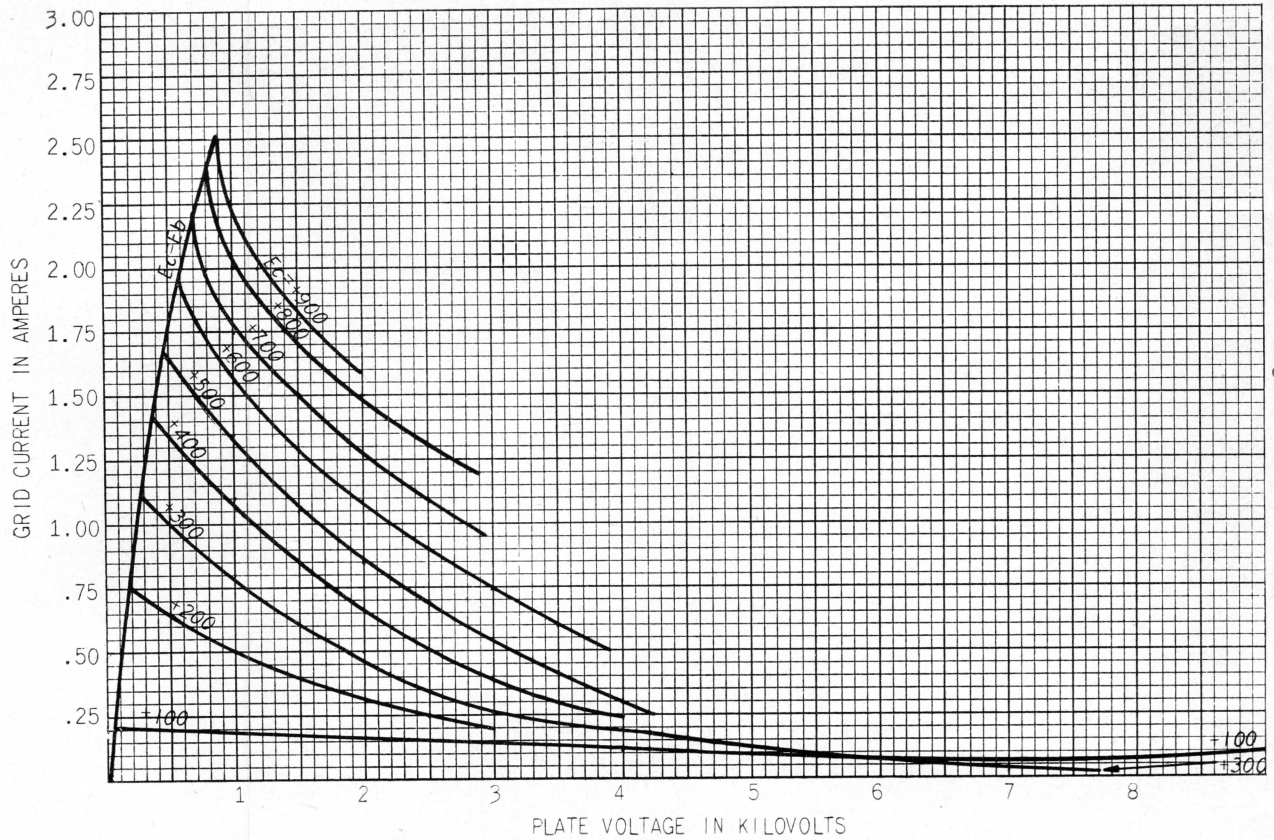
GL-5518 CHARACTERISTICS

 $E_f = 6.3$ VOLTS

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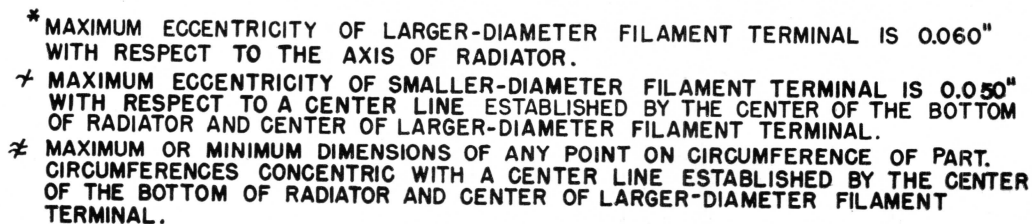
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GL-5518
AVERAGE GRID CHARACTERISTICS
 $E_i = 6.3$ VOLTS



K-69087-47A32

2 19-47



4-27-48

N-20710AZ

Schenectady 5, N. Y.

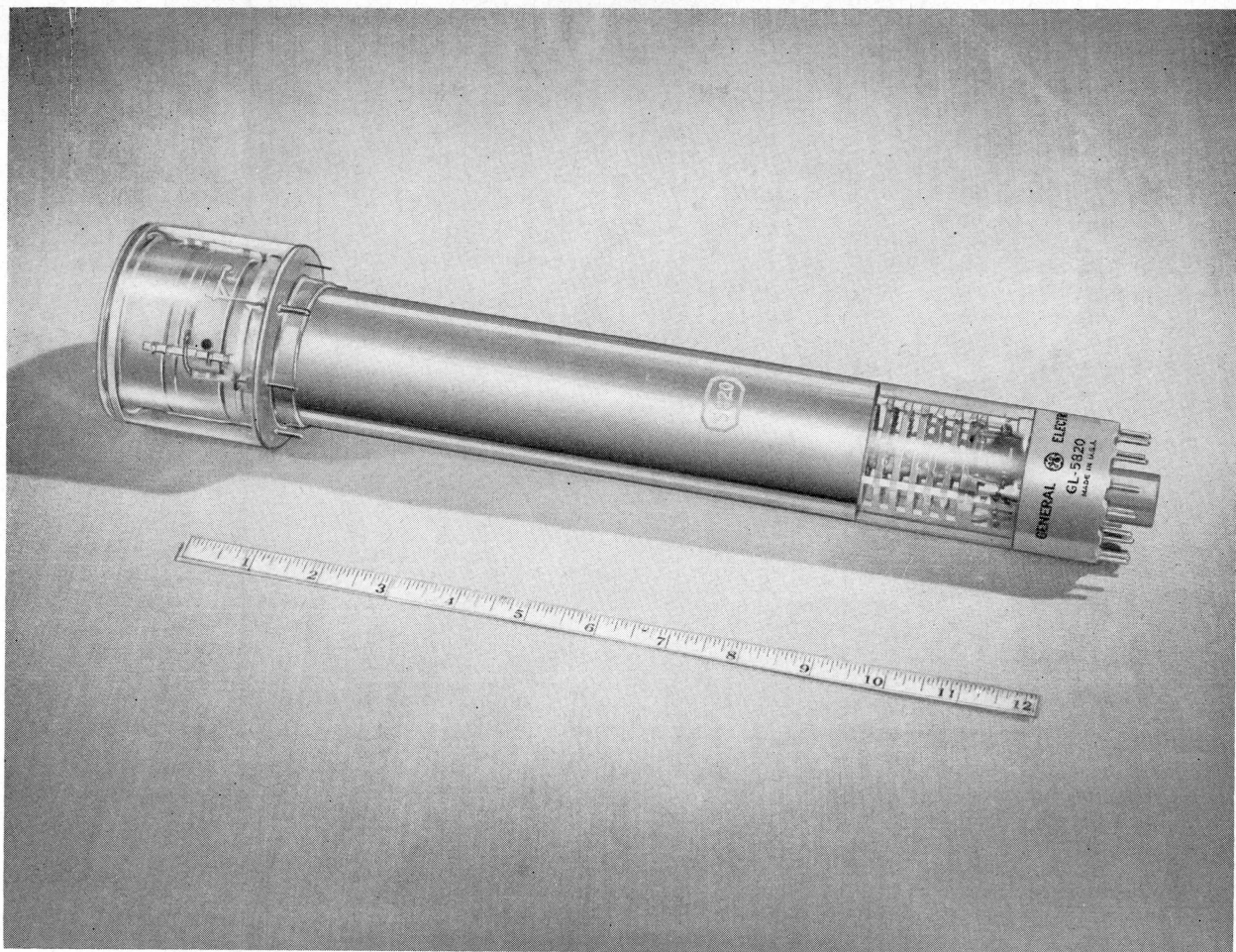


IMAGE ORTHICON

The GL-5820 is a television camera tube for outdoor and studio pickup use in which exceptionally high sensitivity is combined with a spectral response approaching that of the eye. It is very stable in performance at all incident light levels on the object ranging from bright sunlight to a deep shadow (several thousand foot-candles to one foot-candle or less). Commercially acceptable pictures can be obtained at incident light

levels greater than about 10 foot-candles.

The GL-5820 has a photocathode characterized by a spectral response with high blue and high green sensitivity, very good yellow sensitivity, and good red sensitivity. It has practically no infrared sensitivity. This particular characteristic of the response permits portrayal of colors in nearly their true tonal gradation since it prevents any color-masking by infrared.

TECHNICAL INFORMATION

GENERAL

Electrical

Cathode—Unipotential

Heater Voltage, AC or DC $6.3 \pm 10\%$ Volts

Heater Current 0.6 Amperes

Photocathode—Semi-transparent

Response—See spectral sensitivity curve on page 3 for details.

Rectangular Image, 4 by 3 aspect ratio

⊕ Useful Size, maximum diagonal 1.8 Inches

Orientation—Proper orientation is obtained when the vertical scan is essentially parallel to the plane passing through the center of the faceplate and pin No. 7 of the shoulder base.

Focusing Method—Magnetic

Deflecting Method—Magnetic

Direct Interelectrode Capacitance

Anode to All Other Electrodes 12 μf

GENERAL  ELECTRIC

#Supersedes pages 1, 2, 5 and 6 dated 12-56 and 9-57

TECHNICAL INFORMATION (CONT'D)

Mechanical

Over-all Length.....	15.20" $\pm$ 0.25"	Inches
Greatest Diameter of Bulb.....	3.00" $\pm$ 0.06"	Inches
Minimum Deflecting Coil Inside Diameter.....	2 $\frac{3}{8}$	Inches
Deflecting Coil Length.....	5	Inches
Focusing Coil Length.....	10	Inches
Alignment Coil Length.....	1 $\frac{15}{16}$	Inches
Photocathode Distance Inside End of Focusing Coil.....	1 $\frac{1}{2}$	Inches
Weight, approximate.....	1.4	Pounds
Operating Position—Any, except with diheptal base up and the tube axis at an angle of less than 20 degrees from vertical.		

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Maximum Ratings, Absolute Values

Photocathode Voltage.....	—550 Max	Volts
Photocathode Illumination.....	50 Max	Foot-Candles
Anode Supply Voltage*.....	1350 Max	Volts
Grid-No. 1 Voltage		
Negative Bias Value.....	125 Max	Volts
Positive Bias Value.....	0 Max	Volts
Grid-No. 2 and Dynode-No. 1 Voltage.....	350 Max	Volts
Grid-No. 3 Voltage.....	400 Max	Volts
Grid-No. 4 Voltage.....	300 Max	Volts
Grid-No. 5 Voltage.....	150 Max	Volts
Grid-No. 6 Voltage.....	—550 Max	Volts
Voltage Per Multiplier Stage.....	350 Max	Volts
Target Voltage		
Positive Value.....	10 Max	Volts
Negative Value.....	10 Max	Volts
Peak Heater-Cathode Voltage		
Heater Negative with Respect to Cathode.....	125 Max	Volts
Heater Positive with Respect to Cathode.....	10 Max	Volts
Operating Temperature of Any Part of Bulb.....	50 Max	C
Operating Temperature of Bulb at Large End of Tube, target section.....	35 Min	C
Temperature Difference		
Between Target Section and Any Part of Bulb Hotter Than Target Section.....	5 Max	C

Typical Operation

Photocathode Voltage, image focus.....	—400 to —540	Volts
Grid-No. 1 Voltage for Picture Cut-off, beam.....	—45 to —115	Volts
Grid-No. 2 and Dynode-No. 1 Voltage.....	300	Volts
Grid-No. 3 Voltage†, multiplier focus.....	225 to 330	Volts
Grid-No. 4 Voltage, beam focus.....	140 to 180	Volts
Grid-No. 5 Voltage, decelerator.....	0 to 125	Volts
Grid-No. 6 Voltage, accelerator		
75 Percent of Photocathode Voltage, approximate.....	—300 to —405	Volts
Dynode-No. 2 Voltage.....	600	Volts
Dynode-No. 3 Voltage.....	800	Volts
Dynode-No. 4 Voltage.....	1000	Volts
Dynode-No. 5 Voltage.....	1200	Volts
Anode Voltage.....	1250	Volts
DC Anode Current.....	30	Microamperes
⊕Signal Output Current, peak to peak.....	3 to 24	Microamperes
Target Voltage‡		
□Target Cutoff Voltage‡.....	—3 to +1	Volts
Target Temperature Range.....	35 to 45	C
Ratio of Peak-to-Peak Highlight Video Signal		
Current to RMS Noise Current, approximate.....	35	
Minimum Peak-to-Peak Blanking Voltage.....	5	Volts
Field Strength at Center of Focusing Coil§.....	75	Gausses
Field Strength of Alignment Coil, approximate.....	0 to 3	Gausses

* Ratio of dynode voltages is shown under Typical Operation.

† Adjust to give the most uniformly shaded picture near maximum signal.

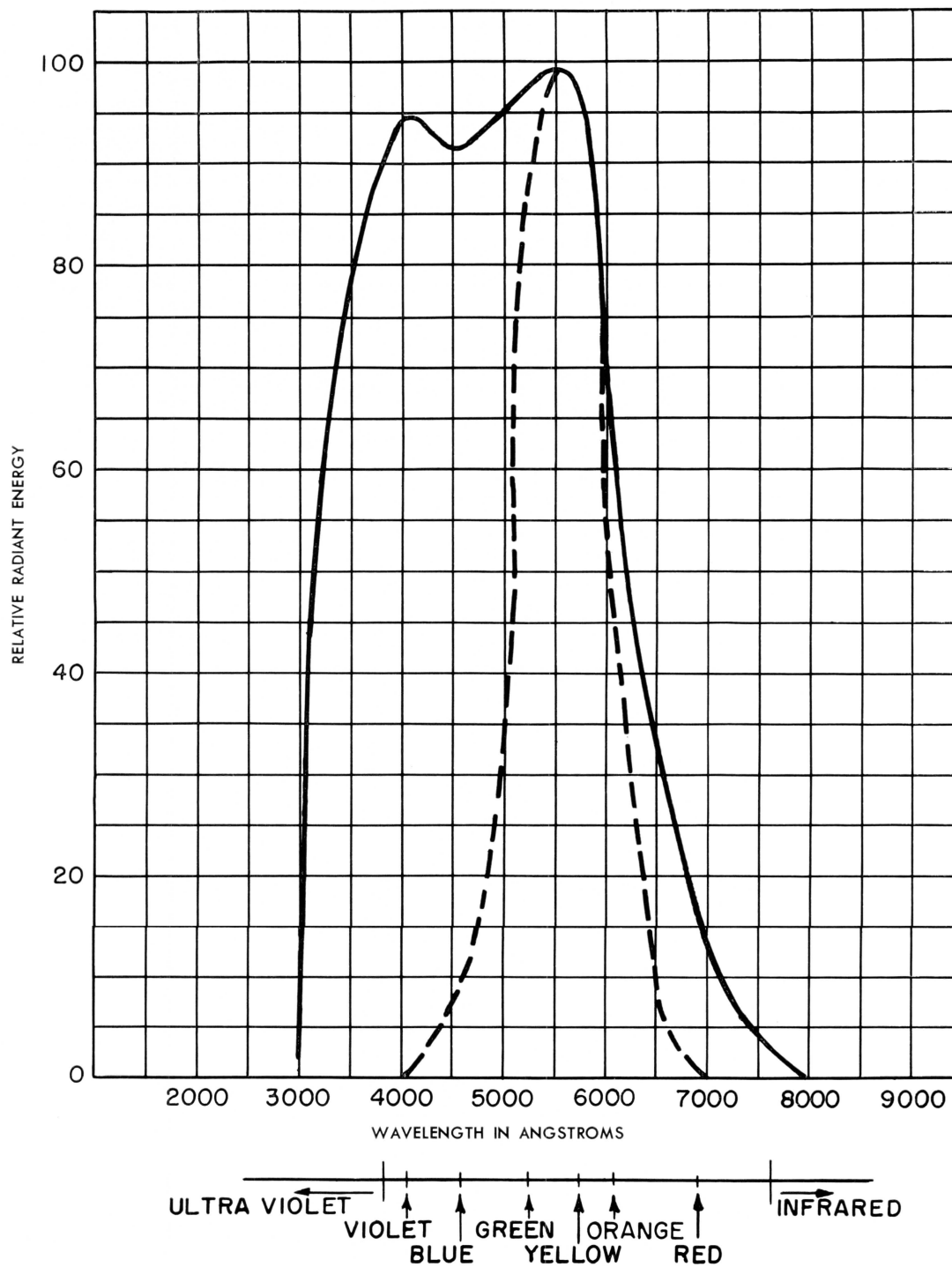
‡ Adjustable from —3 to +5 volts with blanking voltage off. Normal setting of target voltage is +2 volts from target cutoff.

§ Direction of current should be such that a north-seeking pole is attracted to the image end of the focusing coil, with the indicator located outside of and at the image end of the focusing coil.

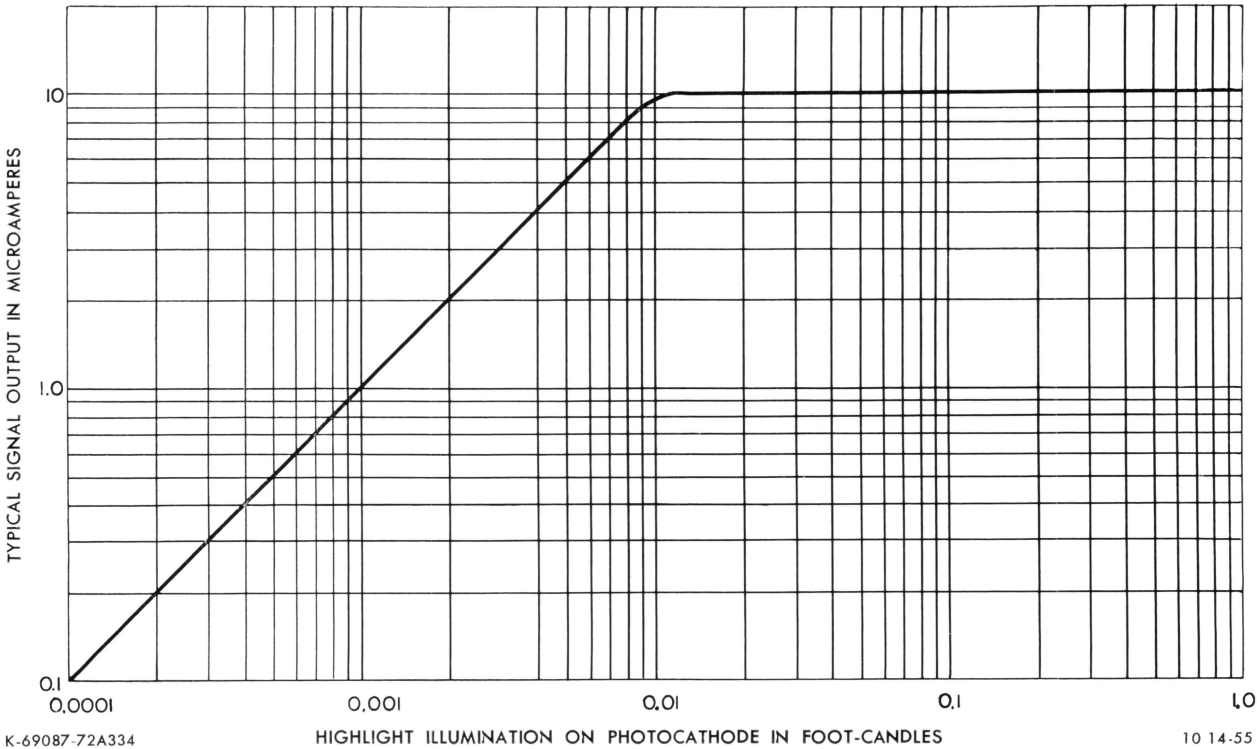
⊕Denotes a change.

□Denotes an addition.

SPECTRAL SENSITIVITY CHARACTERISTIC
FOR EQUAL VALUES OF RADIANT FLUX AT ALL WAVELENGTHS
DASHED CURVE SHOWS SPECTRAL CHARACTERISTIC OF AVERAGE HUMAN EYE



TYPICAL SIGNAL OUTPUT
SCENE: BLACK AND WHITE BALANCED
TUNGSTEN, DAYLIGHT, OR WHITE FLUORESCENT LIGHT

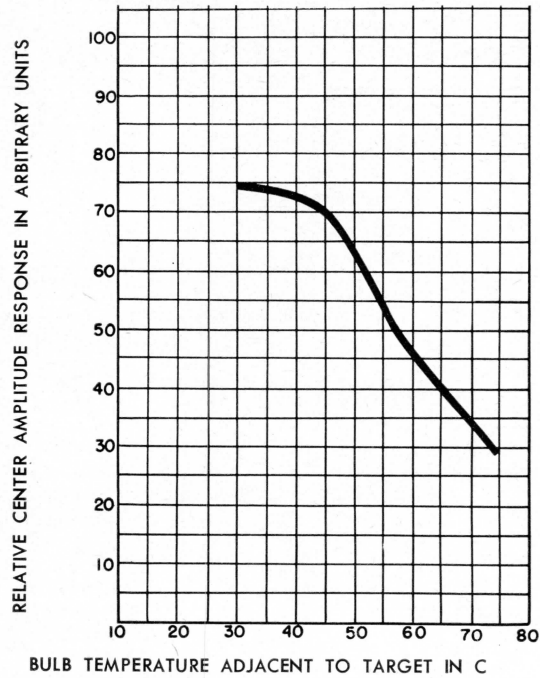


K-69087-72A334

10 14-55

TEMPERATURE EFFECT ON AMPLITUDE RESPONSE

TELEVISION LINE NUMBER = 300



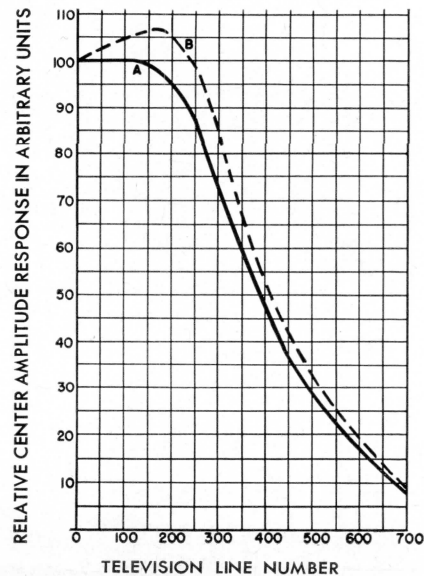
AMPLITUDE RESPONSE CHARACTERISTICS

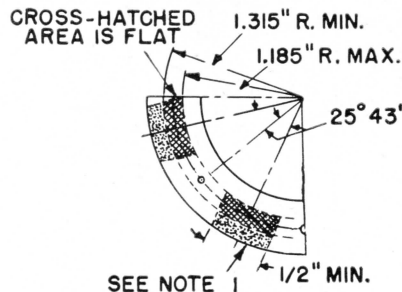
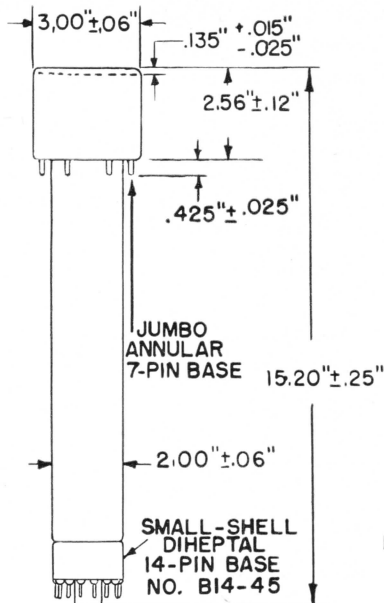
TEST PATTERN: SQUARE WAVE

OPERATING TEMPERATURE OF BULB ADJACENT TO TARGET = 35 C

RESPONSE MEASURED IN SYSTEM HAVING 10 MC BANDWIDTH

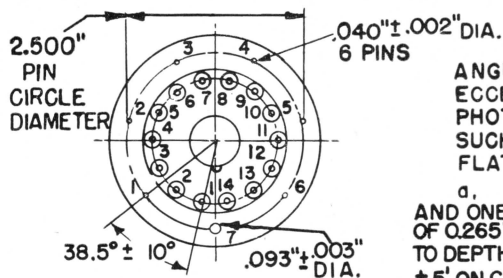
CURVE	HIGHLIGHTS IN RELATION TO LIGHT TRANSFER CHARACTERISTIC
A	AT KNEE
B	ONE LENS STOP ABOVE KNEE





DETAIL OF BOTTOM VIEW OF JUMBO ANNULAR BASE

NOTE 1: DOTTED AREA IS FLAT OR EXTENDS TOWARD DIHEPTAL-BASE END OF TUBE BY 0.060" MAX.



ENLARGED BOTTOM VIEW

ANNULAR BASE GAGE

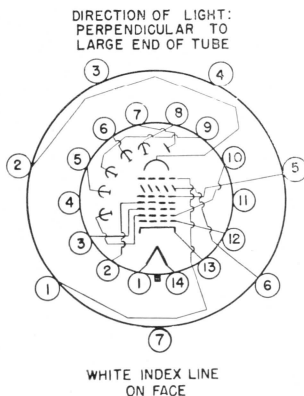
ANGULAR VARIATIONS BETWEEN PINS AS WELL AS ECCENTRICITY OF NECK CYLINDER WITH RESPECT TO PHOTOCATHODE CYLINDER ARE HELD TO TOLERANCES SUCH THAT PINS AND NECK CYLINDER WILL FIT FLAT-PLATE GAGE WITH:

a. SIX HOLES HAVING DIAMETER OF 0.065 ± 0.001 " AND ONE HOLE HAVING DIA. OF 0.150 ± 0.001 ". ALL HOLES HAVE DEPTH OF 0.265 ± 0.001 ". THE SIX 0.065 " HOLES ARE ENLARGED BY 45° TAPER TO DEPTH OF 0.047 ". ALL HOLES ARE SPACED AT ANGLES OF $51^\circ 26' \pm 5'$ ON CIRCLE DIAMETER OF 2.500 ± 0.001 "

b. SEVEN STOPS HAVING HEIGHT OF 0.187 ± 0.001 ", CENTERED BETWEEN PIN HOLES, TO BEAR AGAINST FLAT AREAS OF BASE.

c. RIM EXTENDING OUT A MINIMUM OF 0.125 " FROM 2.812 " DIAMETER AND HAVING HEIGHT OF 0.126 ± 0.001 ".

d. NECK-CYLINDER CLEARANCE HOLE HAVING DIAMETER OF 2.200 ± 0.001 ".



WHITE INDEX LINE ON FACE

SMALL-SHELL DIHEPTAL 14-PIN BASE

PIN 1: HEATER	PIN 6: DYNODE NO. 4	PIN 11: INTERNAL CONNEC -
PIN 2: GRID NO. 4	PIN 7: ANODE	TION-DO NOT USE
PIN 3: GRID NO. 3	PIN 8: DYNODE NO. 5	PIN 12: GRID NO. 1
PIN 4: INTERNAL CONNEC -	PIN 9: DYNODE NO. 3	PIN 13: CATHODE
TION-DO NOT USE	PIN 10: DYNODE NO. 1,	PIN 14: HEATER
PIN 5: DYNODE NO. 2	GRID NO. 2	

KEYED JUMBO ANNULAR 7-PIN BASE

PIN 1: GRID NO. 6	PIN 5: GRID NO. 5
PIN 2: PHOTOCATHODE	PIN 6: TARGET
PIN 3: INTERNAL CONNEC -	PIN 7: INTERNAL CONNEC -
TION-DO NOT USE	TION-DO NOT USE
PIN 4: INTERNAL CONNEC -	
TION-DO NOT USE	

N-15118AZ—Outline Revised

4-23-58

ELECTRONIC COMPONENTS DIVISION

GENERAL  ELECTRIC



KENOTRON

**PLATE DISSIPATION—800 WATTS
THORIATED-TUNGSTEN FILAMENT
RECTIFIER AND LIMITER DIODE**

**LOW VOLTAGE DROP
20 AMPERES AT 75 KILOVOLTS
1.25 AMPERES DC AT 40 KILOVOLTS**

The GL-5973 is a two-electrode high-vacuum tube for use as a rectifier or surge-limiting diode. Design features include a thoriated-tungsten filament and a low voltage drop which enable the tube to carry high average currents.

In rectifier service the tube will operate at average currents as high as 1.25 amperes at 40,000 volts and one ampere at higher voltages. In limiter

service ratings as high as 20 amperes at 75,000 volts apply. These ratings make the tube particularly suitable for use in radar as a charging diode to supply d-c power to magnetrons or as a limiter to restrict fault currents. Other applications include high-voltage power supplies in cable-testing service and smoke precipitators.

TECHNICAL INFORMATION

GENERAL

Electrical

	Minimum	Bogey	Maximum
Filament Voltage.....	15.2	16	16.8 Volts
Filament Current at 16 Volts.....	18.0	19.1	20.2 Amperes
Filament Starting Current.....	—	—	30 Amperes
Filament Cold Resistance.....	—	0.1	— Ohms
Filament Heating Time, before applying plate voltage.....	30	—	— Seconds
Tube Voltage Drop, $I_b = 5$ amperes.....	850	950	1050 Volts
Interelectrode Capacitance.....	—	14	— $\mu\mu\text{f}$

GENERAL  ELECTRIC

§Supersedes pages 1 and 2 dated 12-57

TECHNICAL INFORMATION (Cont'd)

Mechanical

Maximum Glass Temperature*	300 C
Maximum Base Temperature	150 C
Mounting Position—Vertical, Base Down	
Net Weight, approximate	3 Pounds

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Rectifier Service

Maximum Ratings, Absolute Values	
Peak Inverse Voltage	75 Kilovolts
Plate Current	
Peak	5 Amperes
Average	
Peak Inverse Voltage = 40 Kilovolts or Less	1.25 Amperes
Peak Inverse Voltage = more than 40 Kilovolts	1.00 Amperes
Average Plate Dissipation	
Peak Inverse Voltage = 40 Kilovolts or Less†	850 Watts
Peak Inverse Voltage = more than 40 Kilovolts‡	800 Watts

Limiter Service

Maximum Ratings, Absolute Values	
Peak Inverse Voltage	75 Kilovolts
Peak Plate Current	20 Amperes
Average Plate Dissipation‡	800 Watts

*Where tubes are enclosed or operated in close proximity to each other, forced-air cooling may be required to limit bulb and base temperatures to the allowable maximum.

†Maximum observed temperature of 1010 C at any point on the anode.

‡Maximum observed temperature of 985 C at any point on the anode.

□ PERFORMANCE ASSURANCE SPECIFICATION ¶

	Test 1 #	Test 2	Test 3 (plate characteristics)
Filament Voltage, a-c	16.0	16.0	16.0 Volts
Plate Inverse Voltage	75	40	— Kilovolts
Peak Anode Voltage	—	—	850-1050 Volts
Peak Plate Current	3.14	3.92	5.0 Amperes
Average Plate Current, d-c	1.0	1.25	— Amperes
Warm-up Time, minimum	30	30	— Seconds
Duration of Test	10	10	— Minutes

¶These tests are performed to assure that the GL-5973 will operate satisfactorily in accordance with the ratings included on the Description and Rating sheet.

The tube will operate without arcing following the preliminary operating period of 10 minutes.

□ Denotes an addition.

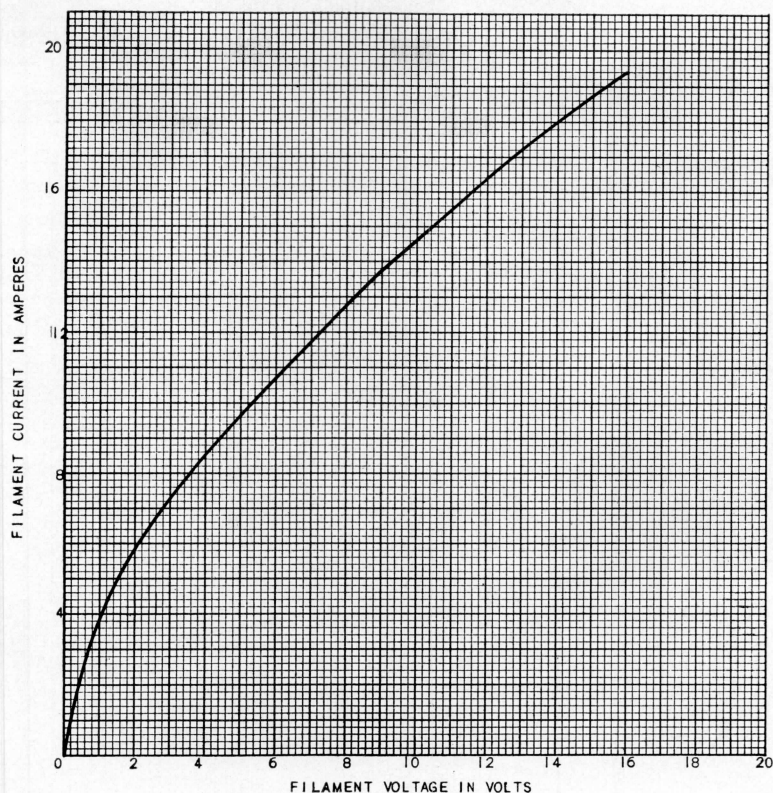
X-RAY WARNING NOTICE

If the GL-5973 is operated at anode voltages in excess of 16 kilovolts, x-ray radiation shielding may be necessary to protect the user against possible danger of personal injury from prolonged exposure at close range. For further information consult the following references or other standard texts on the subject:

(a) *X-Ray Protection Design*, Handbook No. 50. National Bureau of Standards, Washington, D.C.

(b) *X-Ray Protection*, Handbook No. 60. National Bureau of Standards, Washington, D.C.

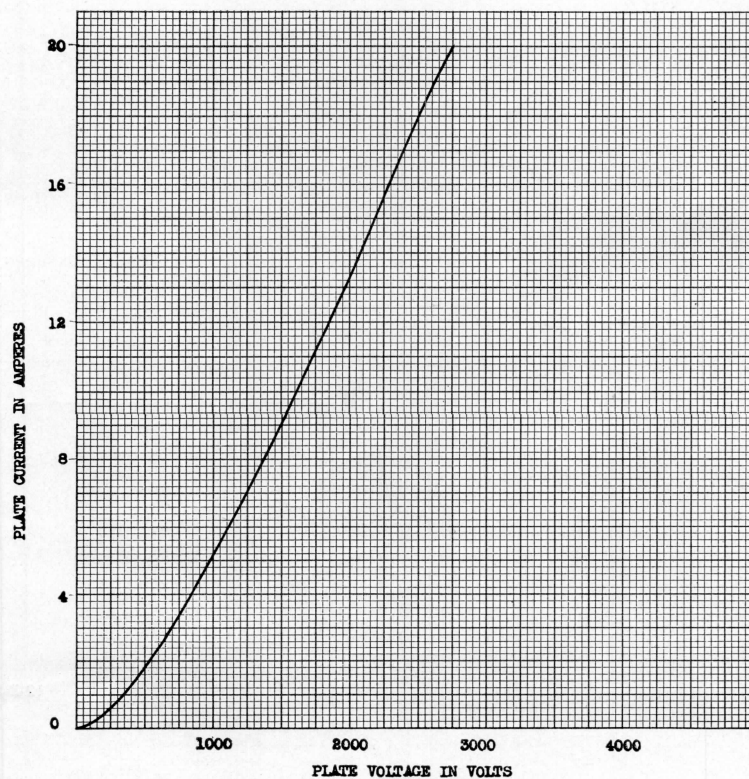
The above references are available from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.



TYPICAL FILAMENT CURRENT CHARACTERISTIC

K-69087-72A380

12-19-50



TYPICAL PLATE CHARACTERISTIC

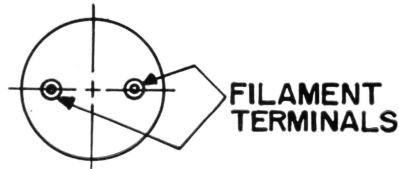
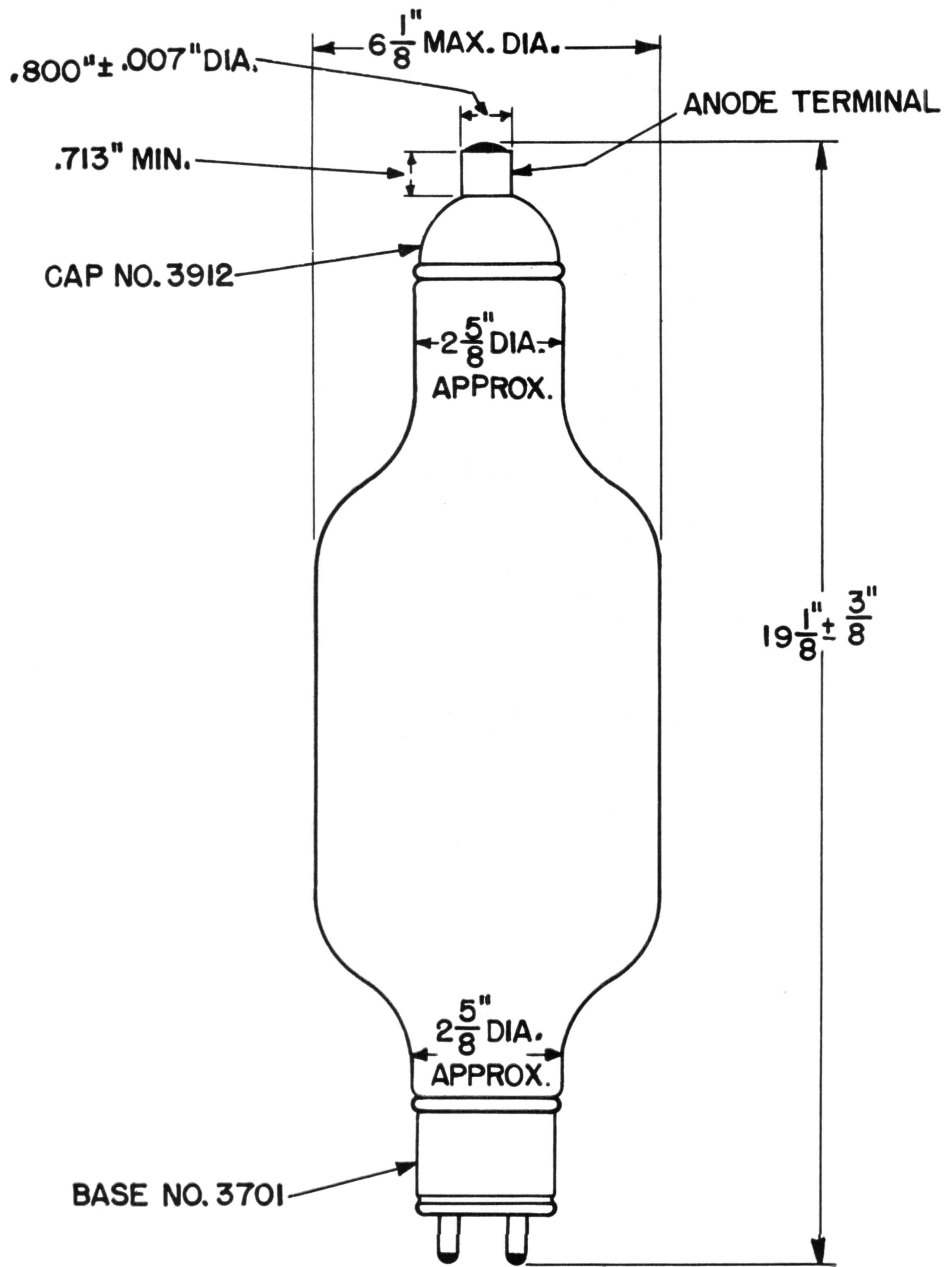
 $E_f = 16$ volts

K-69087-72A381

3-14-52

GL-5973

ET-T1038
PAGE 4
9-53



OUTLINE
GL-5973

N-21009AZ

12-7-50

TUBE DEPARTMENT

GENERAL ELECTRIC

Schenectady 5, N. Y.

PRINTED
IN
U.S.A.



TETRODE

**ONE KILOWATT UHF TELEVISION OUTPUT
UHF TETRODE
GROUNDED-GRID CIRCUITS**

**WATER COOLED
METAL AND CERAMIC
INTEGRAL WATER JACKET**

The GL-6019 is a four-electrode transmitting tube featuring a metal-and-ceramic envelope designed for use as a power amplifier or oscillator in grounded-grid circuits with both grids maintained at radio-frequency ground potential. The output circuit is connected between the anode and the screen grid. The anode is capable of dissipating two kilowatts. Cooling is accomplished by water and forced air with the water jacket an integral part of the anode. The cathode is indirectly heated and thoriated. Maximum ratings apply up to 900 megacycles.

When used as a Class B grounded-grid broadband television amplifier this tube has a useful synchronizing peak-power output of one kilowatt

at 900 megacycles; in narrowband Class C service the output is one kilowatt of continuous power as an amplifier or oscillator. Because of its ratings, the GL-6019 is also well adapted to use in dielectric heating equipment.

The small size and close spacing of electrodes in the design of the tube combine with the ring-seal construction and the low-loss factor due to the gold-over-silver-plated external parts and the ceramic permit high operating efficiency. In addition, the grounded-grid construction eliminates the necessity for neutralization in a properly designed circuit. The small size of the GL-6019 permits compact mounting, and the integral water jacket and ring-seal construction allow quick plug-in installation.

GENERAL  ELECTRIC


**Electronic
TUBE**

TECHNICAL INFORMATION

GENERAL

Electrical	Minimum	Bogey	Maximum	
Heater Voltage*		6.3	6.8	Volts
Heater Current at Bogey Voltage		24		Amperes
Heater Starting Current			36	Amperes
Heater Cold Resistance		0.022		Ohm
Cathode Heating Time	1			Minutes
Amplification Factor, G ₂ to G ₁				
E _b = 500 Volts, I _b = 0.250 Ampere		10		
Peak Cathode Current†			4	Amperes
Direct Interelectrode Capacitances				
Cathode—Plate‡		0.03		uuf
Input, G ₂ tied to G ₁		16.0		uuf
Output G ₂ tied to G ₁ ♦		4.6		uuf
Mechanical				
Mounting Position—Vertical				
Water Flow				
Anode		0.6 Min		Gallon per Minute
Pressure Drop at Rated Flow		3.5		Pounds per Square Inch
Water Pressure		80 Max		Pounds per Square Inch
Outlet Water Temperature		70 Max		C
Air Flow¶				
Heater to Cathode Seals		12 Min		Cubic Feet per Minute
Screen-Grid to Control-Grid Seals		6 Min		Cubic Feet per Minute
Anode to Screen-Grid Ceramic Insulator		6 Min		Cubic Feet per Minute
Ceramic Temperature at any Point		200		C
Net Weight, approximate		1.25		Pounds

Water and air cooling to be applied before and during the application of any voltages. Water cooling may be discontinued with removal of all voltages. Air flow on heater-to-cathode seal must be maintained for one minute after removal of heater voltage.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

RADIO-FREQUENCY AMPLIFIER—CLASS B TELEVISION SERVICE

Synchronizing-Level Conditions per Tube Unless Otherwise Specified

Maximum Ratings, Absolute Values

DC Plate Voltage	4000 Max	Volts
DC Grid-No. 2 Voltage	600 Max	Volts
DC Plate Current	0.7 Max	Ampere
Plate Input	2.5 Max	Kilowatts
Grid-No. 2 Input	25 Max	Watts
Plate Dissipation	2.0 Max	Kilowatts
Grid-No. 1 Dissipation	16 Max	Watts

Typical Operation—Grounded-Grid Circuit up to 900 Megacycles

Bandwidth 6 megacycles		
DC Plate Voltage	3500	Volts
DC Grid-No. 2 Voltage	500	Volts
DC Grid-No. 1 Voltage	—40	Volts
Peak RF Plate Voltage		
Synchronizing Level	2500	Volts
Pedestal Level	1875	Volts
Peak RF Driving Voltage		
Synchronizing Level	110	Volts
Pedestal Level	70	Volts
DC Plate Current		
Synchronizing Level	0.520	Ampere
Pedestal Level	0.360	Ampere
DC Grid-No. 2 Current (Pedestal Level)	0.035	Ampere
DC Grid-No. 1 Current		
Synchronizing Level	0.110	Ampere
Pedestal Level	0.035	Ampere

TECHNICAL INFORMATION (CONT'D)

Driving Power at Tube, approximate		
Synchronizing Level	100	Watts
Pedestal Level	25	Watts
Power Output, approximate		
Synchronizing Level π	1000	Watts
Pedestal Level π	560	Watts

PLATE-MODULATED RADIO-FREQUENCY POWER AMPLIFIER—CLASS C TELEPHONY

Carrier Conditions with a Maximum Modulation Factor of 1.0

Maximum Ratings, Absolute Values

DC Plate Voltage	3200 Max	Volts
DC Grid-No. 2 Voltage	600 Max	Volts
DC Grid-No. 1 Voltage	—120 Max	Volts
DC Plate Current	0.35 Max	Ampere
DC Grid-No. 1 Current	0.10 Max	Ampere
Plate Input	1.12 Max	Kilowatts
Grid-No. 2 Input	10 Max	Watts
Plate Dissipation	1200 Max	Watts

Typical Operation—Grounded-Grid Circuit

DC Plate Voltage	3000	Volts
DC Grid-No. 2 Voltage	500	Volts
DC Grid-No. 1 Voltage	—100	Volts
Peak RF Plate Voltage	2300	Volts
Peak RF Driving Voltage	137	Volts
DC Plate Current	0.25	Ampere
DC Grid-No. 2 Current	0.01	Ampere
DC Grid-No. 1 Current, approximate	0.047	Ampere
Driving Power, approximate ψ	38	Watts
Power Output#	565	Watts

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

Key-Down Conditions per Tube Without Amplitude Modulation Δ

Maximum Ratings, Absolute Values

DC Plate Voltage	4000 Max	Volts
DC Grid-No. 2 Voltage	600 Max	Volts
DC Grid-No. 1 Voltage	—150 Max	Volts
DC Plate Current	0.7 Max	Ampere
DC Grid-No. 1 Current	0.10 Max	Ampere
Plate Input	2.8 Max	Kilowatts
Grid-No. 2 Input	25 Max	Watts
Plate Dissipation	2 Max	Kilowatts
Grid-No. 1 Dissipation	16 Max	Watts

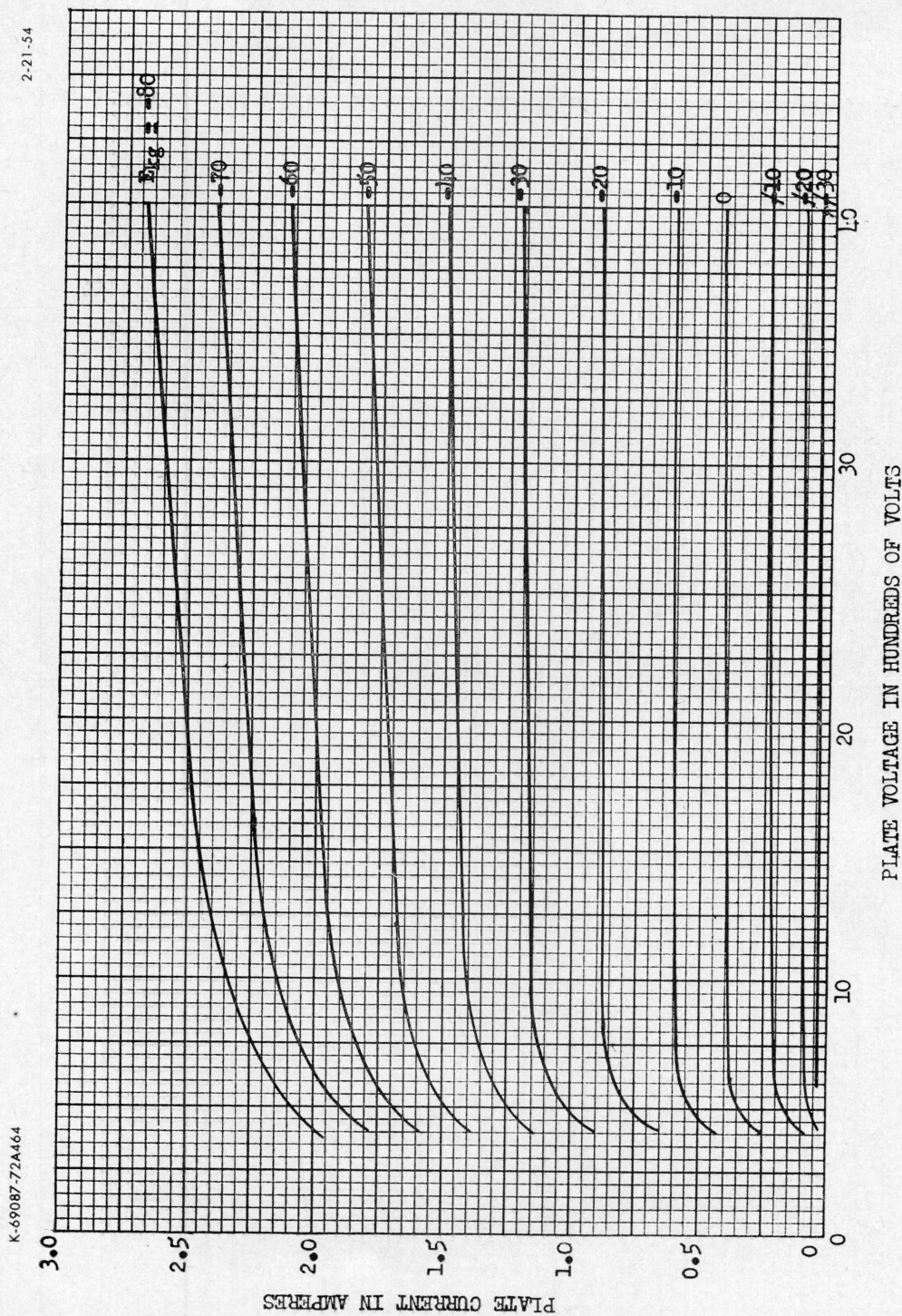
Typical Operation

DC Plate Voltage	4000	Volts
DC Grid-No. 2 Voltage	600	Volts
DC Grid-No. 1 Voltage	—120	Volts
Peak RF Plate Voltage, approximate	2750	Volts
Peak RF Grid-No. 1 Voltage	195	Volts
DC Plate Current	0.550	Ampere
DC Grid-No. 2 Current	0.035	Ampere
DC Grid-No. 1 Current, approximate	0.065	Ampere
Driving Power, approximate	150	Watts
Power Output, approximate#	1200	Watts

*The cathode of the GL-6019, because of transit-time effects which raise the temperature of the cathode, is subjected to considerable back bombardment in ultra-high-frequency service. The amount of heating due to bombardment is a function of the operating conditions and frequency, and must be compensated for by a reduction of the heater input to prevent overheating of the cathode with resulting short life. For long life, the GL-6019 should be put in operation with rated heater voltage. After the circuit has been adjusted for proper tube operation the heater voltage should be reduced to a value slightly above that at which circuit performance is affected. At a frequency of 900 megacycles and with typical operating conditions the heater voltage can be reduced to approximately 5 volts. At lower frequencies, the reduction will be less. Minor circuit readjustment may be necessary after this adjustment.

TECHNICAL INFORMATION (CONT'D)

- †Represents maximum usable cathode current (plate current plus current to each grid) for any condition of operation.
- ‡Measured with a 6-inch diameter flat metal disk attached to the screen-grid ring. Control grid connected to the screen grid.
- ◆Output capacitance measured between anode and screen grid. Control grid connected directly to screen grid.
- ¶The volume of cooling air indicated for the various seals is approximate only. Distribution of cooling air will vary with the cavity configuration about the tube. For most satisfactory operation the maximum temperature of any point on the tube shall be below 200 C.
- πUseful power output including power transferred from driver stage.
- ΔModulation essentially negative may be used if the positive peak of the envelope does not exceed 115 percent of the carrier conditions.
- #Total anode power output including power transferred from driver stage.
- ψThe carrier of the driver modulated 100 percent.



GL-6019

AVERAGE PLATE CHARACTERISTICS

 $E_f = 6.3$ VOLTS SCREEN VOLTAGE = 500 VOLTS

CONTROL-GRID GROUNDED ELECTRODE VOLTAGES MEASURED TO GROUND

GL-6019
CONSTANT-CURRENT CHARACTERISTICS
 $E_f = 6.3$ VOLTS
SCREEN VOLTAGE = 500 VOLTS
CONTROL-GRID GROUNDED ELECTRODE VOLTAGES MEASURED TO GROUND

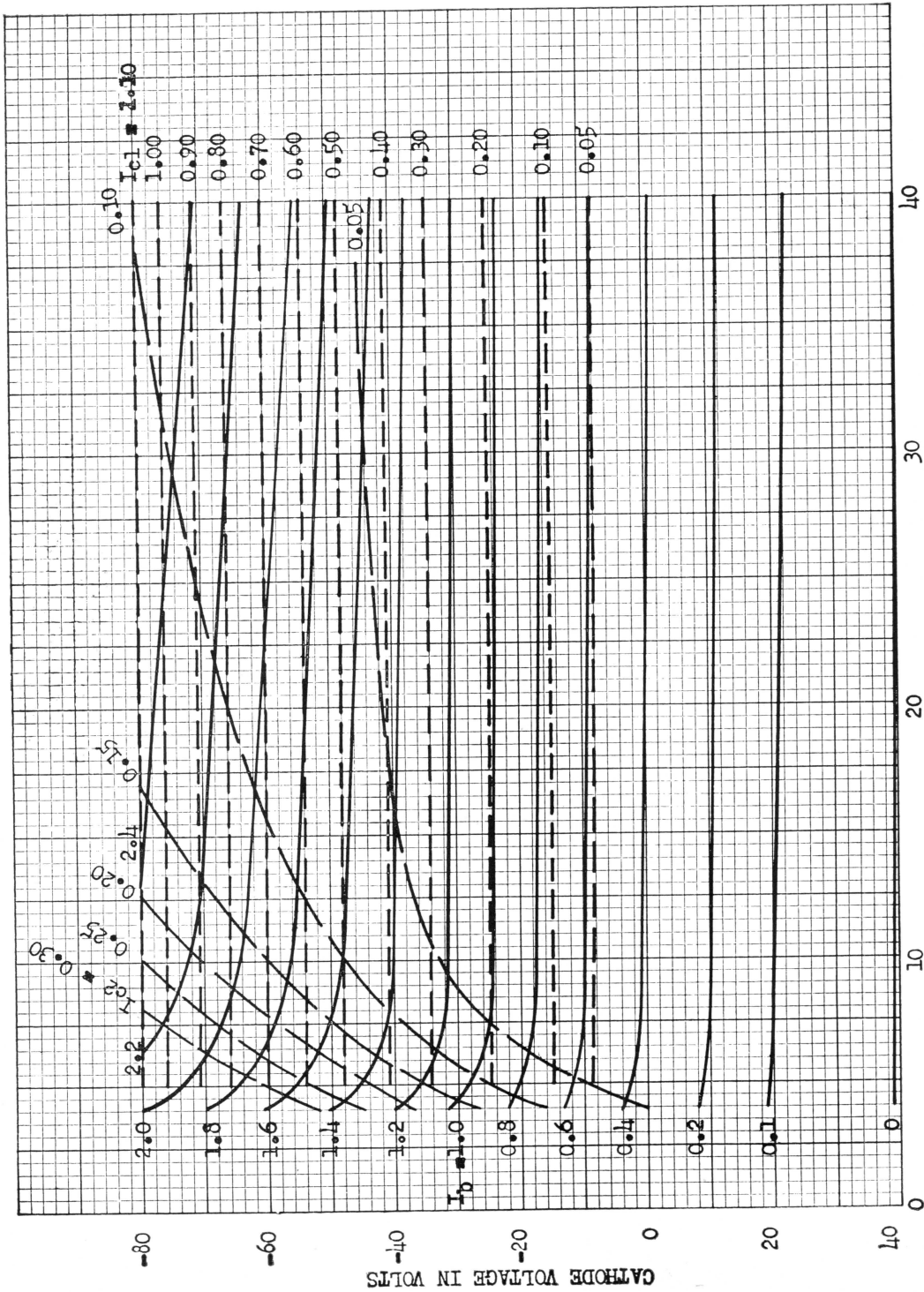
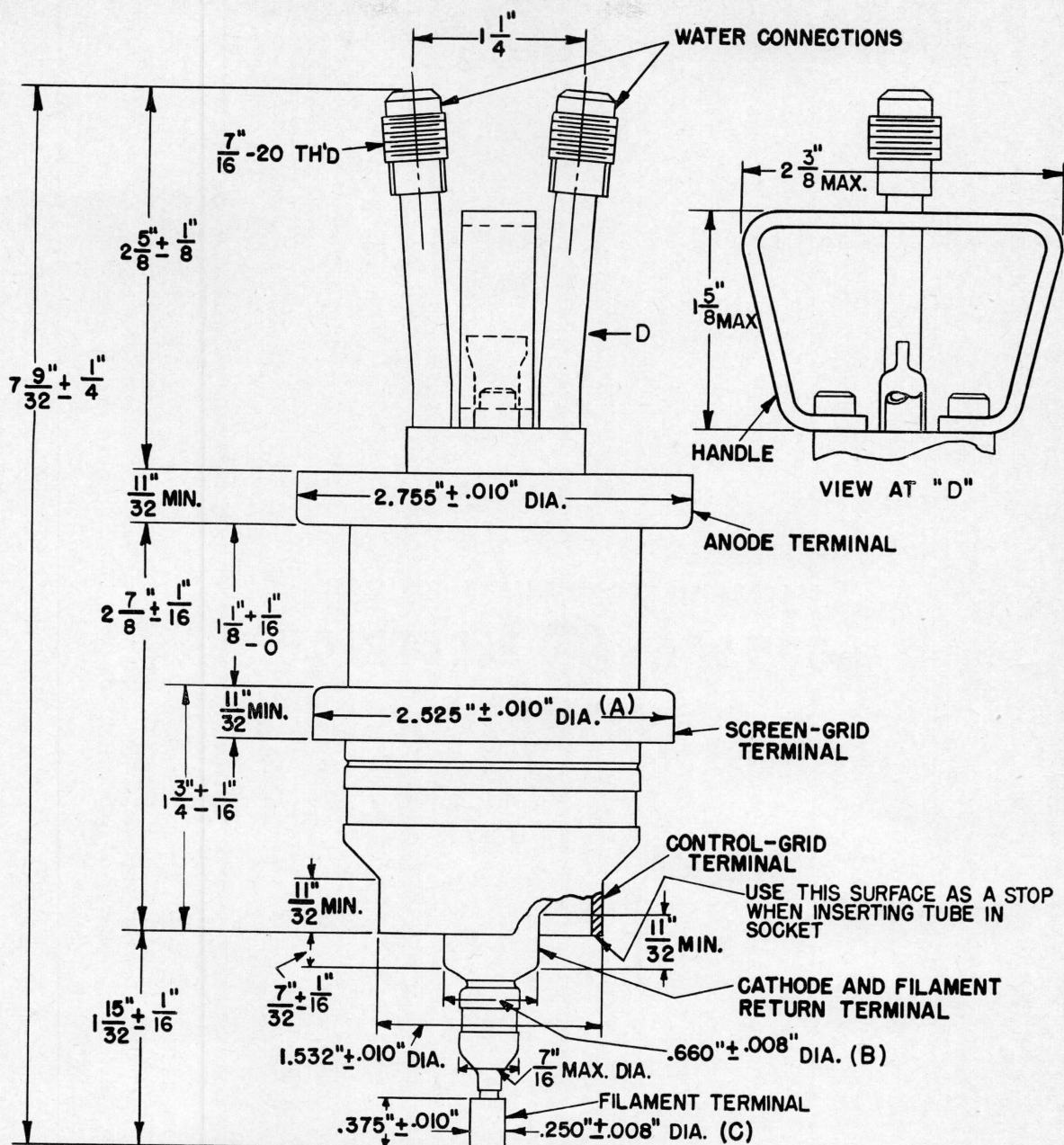


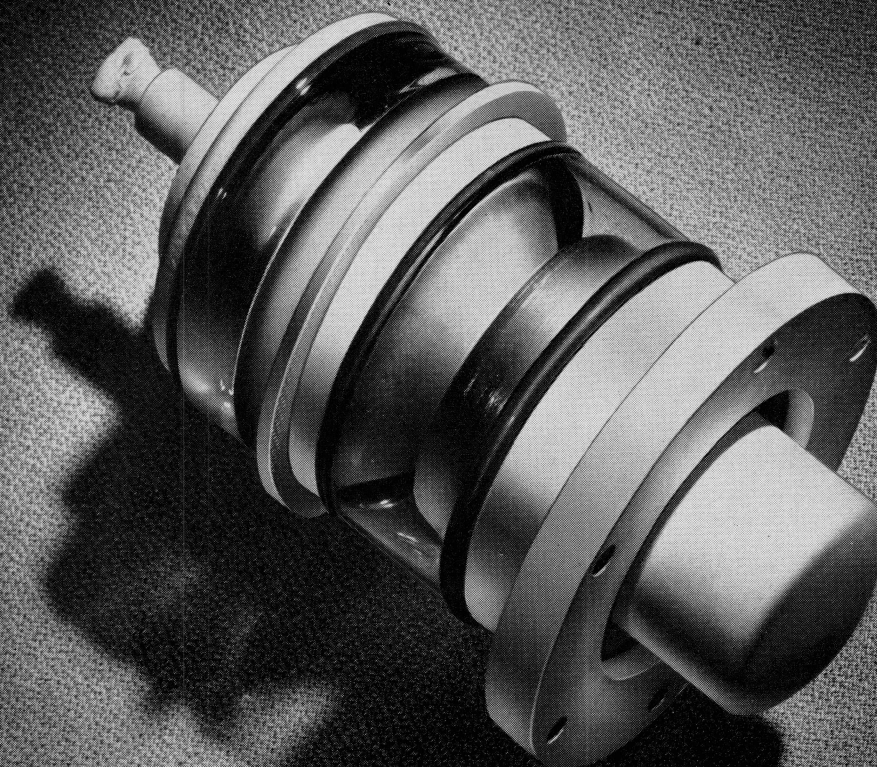
PLATE VOLTAGE IN HUNDREDS OF VOLTS



(A) MAXIMUM ECCENTRICITY 0.010"
 (B) MAXIMUM ECCENTRICITY 0.015"
 (C) MAXIMUM ECCENTRICITY 0.030"
 WITH RESPECT TO CENTERLINE DETERMINED BY CENTERS
 OF ANODE TERMINAL AND CONTROL-GRID TERMINAL.

OUTLINE
 GL-6019

ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
Schenectady 5, N. Y.



TRIODE

VHF TELEVISION
FM
GROUNDED-GRID CIRCUIT

WATER COOLED
THORIATED-TUNGSTEN FILAMENT
LOW LEAD INDUCTANCE

The GL-6039 is a three-electrode tube designed for use as a grounded-grid class B radio-frequency amplifier and class C radio-frequency amplifier and oscillator in television and FM services. The anode is water-cooled and capable of dissipating 7 kilowatts. The cathode is a thoriated-tungsten filament. Maximum ratings apply up to 220 megacycles.

Utilizing the same general design principles that have proved so successful in the operation of the GL-9C24, this tube's predecessor, the GL-6039 has several features that enable it to give improved service over the older tube in both the television and FM bands. A material reduction in power cost results from use of a thoriated-tungsten filament which requires only 25.8 percent of the amount of

power required. Higher output can be obtained—a pair of GL-6039's are capable of 10 kilowatts output in television service and 25 kilowatts in FM. Other features of the tube are low lead inductance, large terminal-contact areas, and silver-plated metal parts to reduce radio-frequency losses. In addition, neutralization is unnecessary in a properly designed circuit, and the problem of filament starting is eliminated since special precautions to limit the filament starting current are not required.

The GL-6039 can be substituted for the GL-9C24 with a saving of 74.2 percent in filament power providing modification of the filament circuit and minor mechanical changes are made.

TECHNICAL INFORMATION

GENERAL

Electrical

	Minimum	Bogey	Maximum
Filament Voltage.....	4.8	5.0	5.2 Volts

GENERAL  ELECTRIC


Electronic
TUBE

TECHNICAL INFORMATION (CONT'D)

Filament Current at 5 Volts.....	74	78	82 Amperes
Amplification Factor, $I_b = 1.0$ amp, $E_c = -50V$	17	21	25
Interelectrode Capacitances			
Grid-Plate.....	13.8	15.7	17.6 uuf
Grid-Filament.....	20	24	28 uuf
Plate-Filament*.....	0.34	0.47	0.60 uuf

Mechanical

Mounting Position—Vertical, Anode Down	
Type of Cooling—Water and Forced Air	
Water Flow on Anode.....	11 GPM
Maximum Outgoing Water Temperature.....	70 C
Air Flow to Center Filament Terminal.....	7 CFM
Maximum Glass Temperature§.....	150 C
Gasket—JETEC Type No. 19	
Net Weight, approximate.....	3.5 Pounds

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

RADIO-FREQUENCY POWER AMPLIFIER—CLASS B VIDEO SERVICE

Synchronizing peak conditions per tube in a grounded-grid circuit—5 megacycles bandwidth

Maximum Ratings, Absolute Values

D-C Plate Voltage.....	6000 Max Volts
D-C Plate Current.....	2.25 Max Amperes
Plate Input.....	13.5 Max Kilowatts
Plate Dissipation.....	7 Max Kilowatts

Typical Operation

D-C Plate Voltage.....	5000	5000	Volts
D-C Grid-No. 1 Voltage.....	270	300	Volts
Peak R-f Grid-No. 1 Voltage.....	700	580	Volts
D-C Plate Current.....	2.2	2.1	Amperes
D-C Grid-No. 1 Current, approximate.....	0.21	0.17	Ampere
Driving Power, approximate†.....	1300	1060	Watts
Power Output, approximate†.....	5.6	4.9	Kilowatts

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values

D-C Plate Voltage.....	7500 Max Volts
D-C Grid-No. 1 Voltage.....	1000 Max Volts
D-C Plate Current.....	2.25 Max Amperes
D-C Grid-No. 1 Current.....	0.400 Max Ampere
Plate Input.....	16 Max Kilowatts
Plate Dissipation.....	7 Max Kilowatts

Typical Operation, Grounded-Filament Circuit

D-C Plate Voltage.....	7000	Volts
D-C Grid-No. 1 Voltage.....	900	Volts
Peak R-f Grid-No. 1 Voltage.....	1540	Volts
D-C Plate Current.....	2.08	Amperes
D-C Grid-No. 1 Current, approximate.....	0.40	Ampere
Driving Power, approximate.....	620	Watts
Power Output, approximate.....	10	Kilowatts

Typical Operation, Grounded-grid Circuit

D-C Plate Voltage.....	7000	Volts
D-C Grid-No. 1 Voltage.....	900	Volts
Peak R-f Grid-No. 1 Voltage.....	1540	Volts
D-C Plate Current.....	2.08	Amperes

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS (CONT'D)

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY (CONT'D)

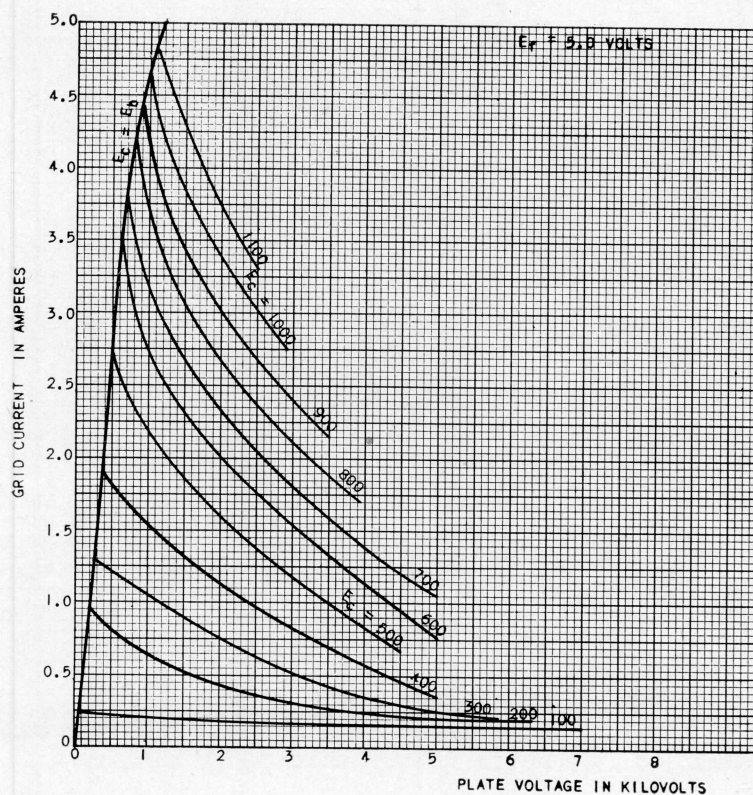
D-C Grid-No. 1 Current, approximate.....	0.40	Ampere
Driving Power, approximate†.....	3.4	Kilowatts
Power Output, approximate†.....	12.8	Kilowatts

* Measured with a 10-inch outer diameter and 3 $\frac{5}{8}$ -inch inner diameter flat shield on grid terminal.

§ Sufficient air flow must be applied to the grid-anode and grid-cathode seals to limit the temperature to this value.

† This value includes power transferred from driver to output.

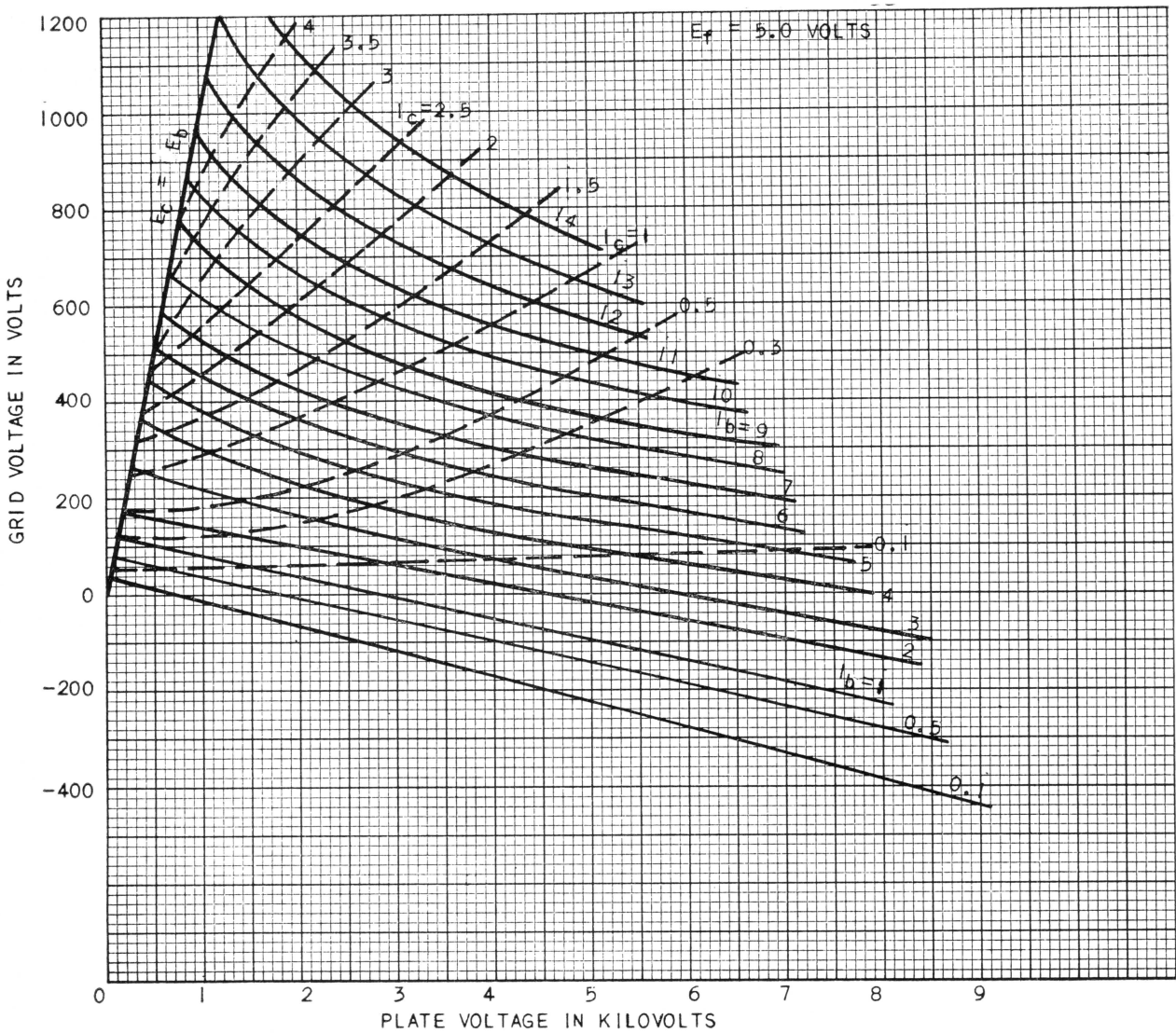
‡ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 percent of the carrier conditions.

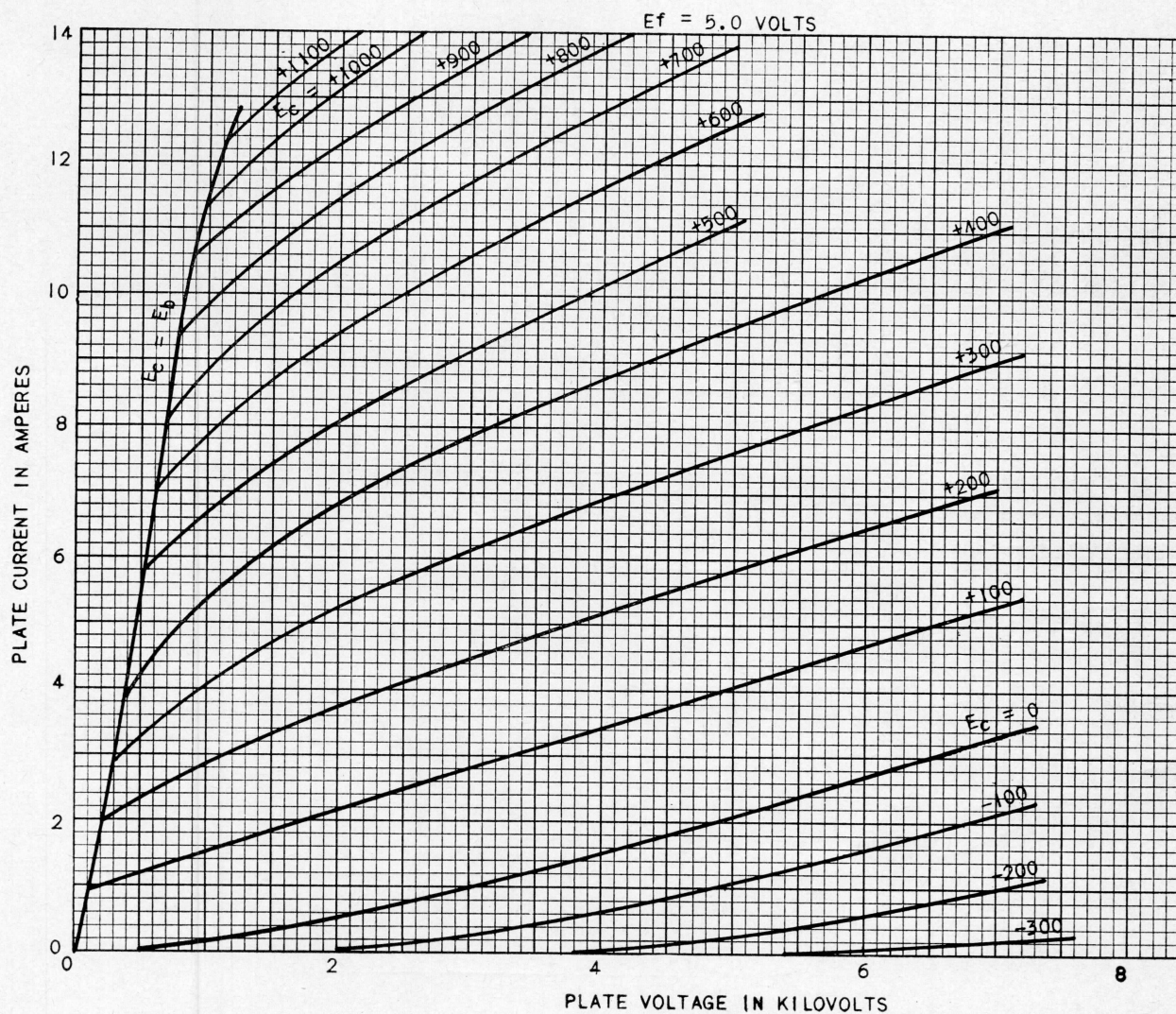


AVERAGE GRID CHARACTERISTICS

K-69087-72A416

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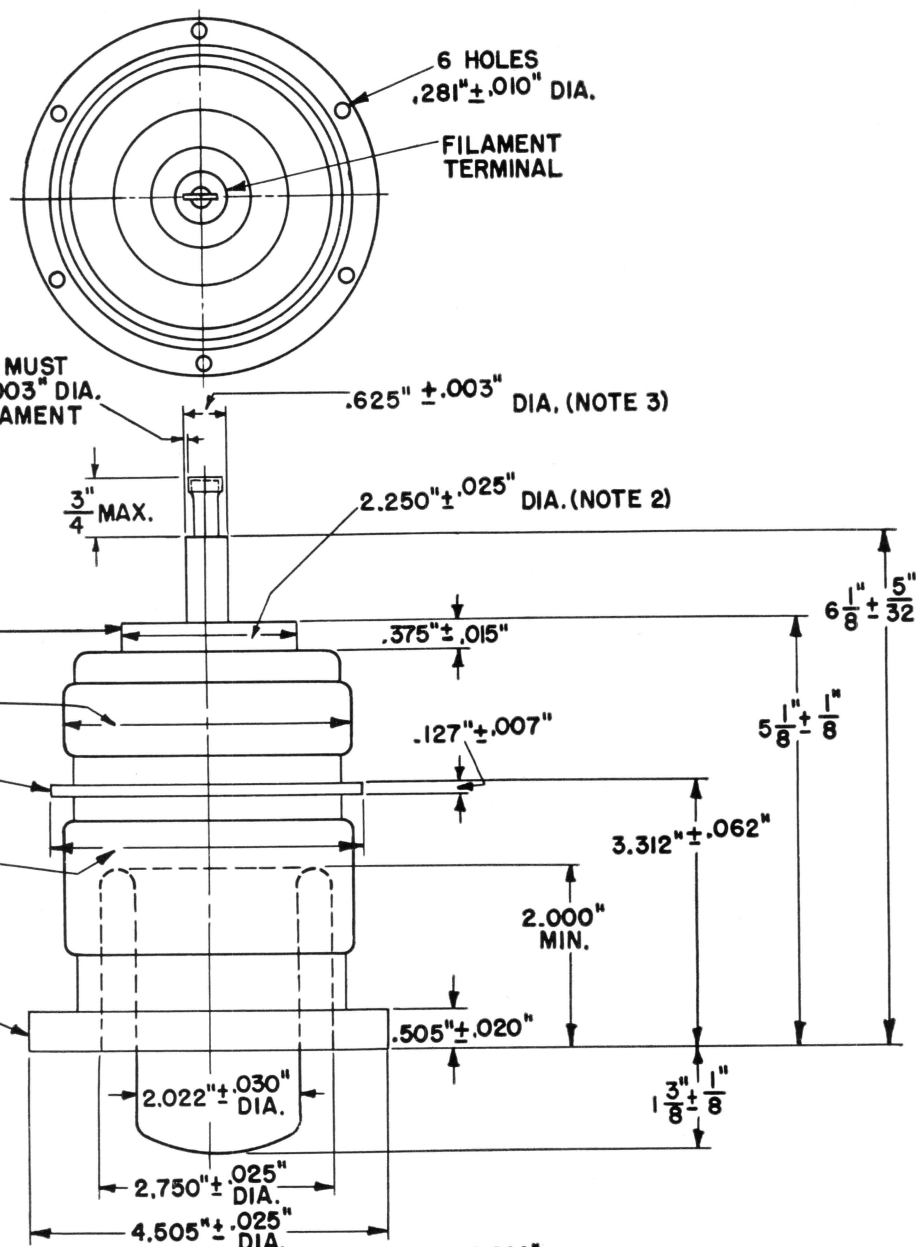




K-69087-72A415

3-24-52

AVERAGE PLATE CHARACTERISTICS



NOTES:

1. HOLES IN ANODE TERMINAL POSITIONED TO FIT SIX .250" $\pm$.002" DIA. PINS INSERTED TO DEPTH OF FLANGE AND LOCATED ON A CIRCLE 4.000" $\pm$.003" DIA. AT ANGLES OF 60 $\pm$ 0 DEG. 10'.
2. ECCENTRICITY .060" FROM CENTER LINE OF OUTSIDE CIRCUMFERENCE OF ANODE TERMINAL.
3. ECCENTRICITY .060" FROM CENTER LINE OF OUTSIDE CIRCUMFERENCE OF PLATE-RETURN TERM.
4. ECCENTRICITY .030" FROM CENTER LINE OF OUTSIDE CIRCUMFERENCE OF ANODE TERMINAL.

OUTLINE
GL-6039

N-15176AZ

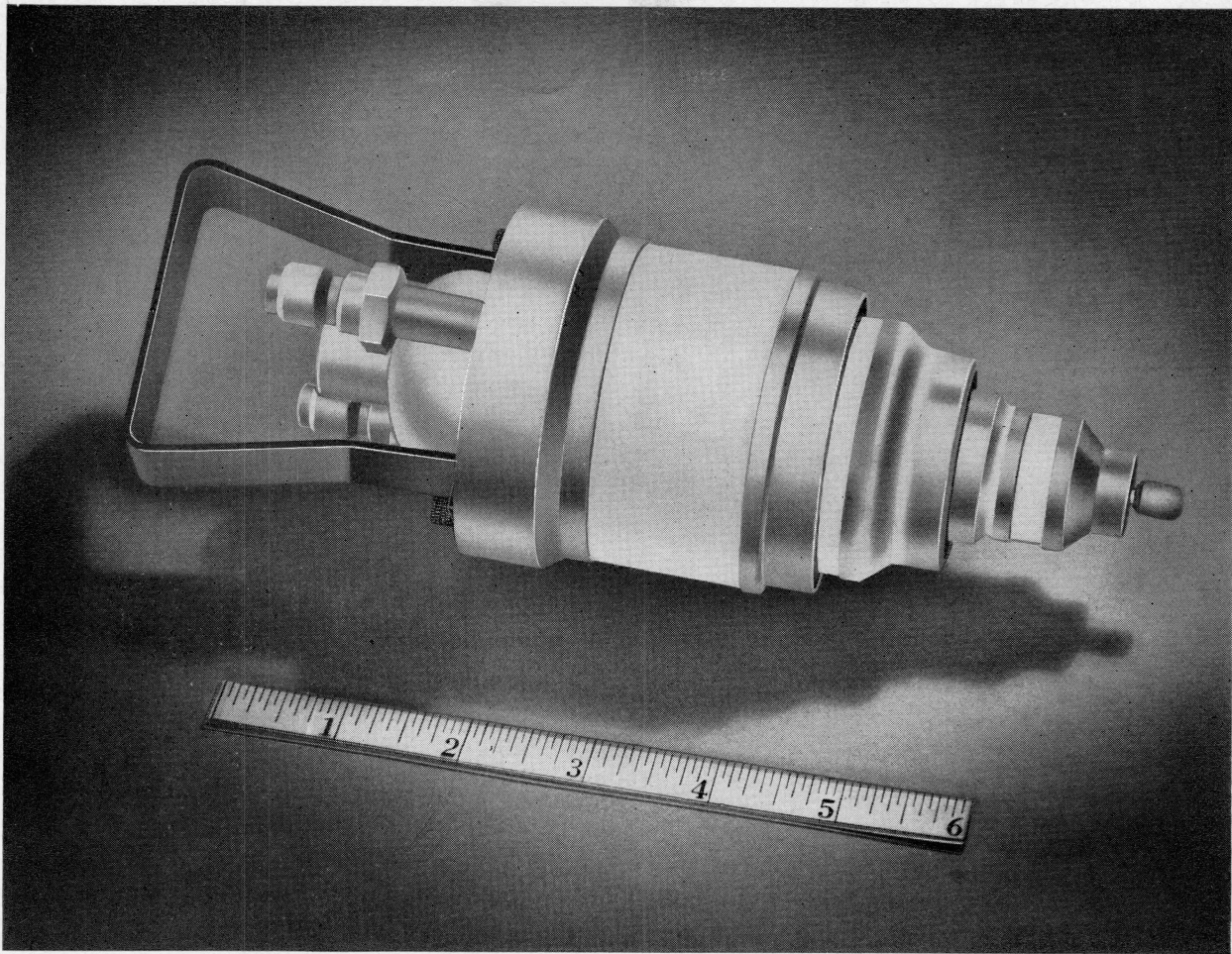
6-17-53

ELECTRONIC COMPONENTS DIVISION

GENERAL  ELECTRIC

Schenectady 5, N. Y.

PRINTED
IN
U.S.A.



TETRODE

WATER COOLED

METAL AND CERAMIC

GROUND-GRID CIRCUIT

INTEGRAL WATER JACKET

UHF TETRODE, RING SEAL CONSTRUCTION

The GL-6182 is a four-electrode transmitting tube featuring a metal-and-ceramic envelope designed for use as a power amplifier or oscillator in grounded-grid circuits with both grids maintained at radio-frequency ground potential. The output circuit is connected between the anode and the screen grid. The anode is capable of dissipating three kilowatts. Cooling is accomplished by water and forced air with the water jacket an integral part of the anode. The cathode is indirectly heated and thoriated. Maximum ratings apply up to 900 megacycles.

In narrow band Class C, grounded-grid, ampli-

tude-modulated service this tube has a useful carrier power output in excess of one kilowatt. In Class C telegraphy, the useful output is 1.5 kilowatts of continuous power as an amplifier or oscillator.

High operating efficiency is assured because of the small size and close spacing of the tube electrodes, the ring-seal construction, and the ceramic insulator. In addition, the grounded-grid construction eliminates the necessity for neutralization in a properly designed circuit. The small size of the GL-6182 permits compact mounting, and the integral water jacket and ring-seal construction allow quick plug-in installation.

GENERAL  ELECTRIC

TECHNICAL INFORMATION

GENERAL

Electrical	Minimum	Bogey	Maximum
Heater Voltage.....		6.7	7.0 Volts
Heater Current at 7.0 Volts			
Without Cathode Bombing.....		15	Amperes
With Cathode Bombing.....		14	Amperes
Heater Starting Current.....			25 Amperes
Heater Cold Resistance.....		0.041	Ohms
Cathode Bombarding Power*.....		115	180 Watts
Cathode Bombarding Voltage, DC.....			700 Volts
Cathode Bombarding Current, DC.....			0.3 Amperes
Cathode Heating Time.....	1		Minutes
Amplification Factor, G ₂ to G ₁			
⊕E _b = 4000 Volts, I _b = 0.500 Amperes, E _{c2} = 500 Volts.....		20	
Peak Cathode Current†.....			9 Amperes
Direct Interelectrode Capacitances			
⊕Cathode to Plate‡.....		0.01	μμf
Input, G ₂ tied to G ₁		29.0	μμf
Output, G ₂ tied to G ₁ §.....		6.6	μμf

Mechanical

⊕Mounting Position—Vertical, Anode-End Up		
Net Weight, approximate.....	2	Pounds

Thermal

Water Flow		
Anode.....	3.0 Min	Gallons per Minute
Pressure Drop at Rated Flow♦.....	20 Max	Pounds per Square Inch
Water Pressure.....	80 Max	Pounds per Square Inch
Outlet Water Temperature.....	70 Max	C
Air Flow		
Screen-Grid to Control-Grid Seals.....	15 Min	Cubic Feet per Minute
Heater-to-Cathode Seals.....	7.5 Min	Cubic Feet per Minute
Anode Ceramic.....	10 Min	Cubic Feet per Minute
Ceramic Temperature at any Point.....	200 Max	C

Water and forced-air cooling to be applied before and during the application of any voltages. Water cooling may be discontinued with removal of all voltages. Air flow on heater-to-cathode seals must be maintained for one minute after removal of heater voltage.

MAXIMUM RATINGS AND TYPICAL OPERATION

PLATE-MODULATED RADIO-FREQUENCY POWER AMPLIFIER—CLASS C TELEPHONY

Carrier Conditions with a Maximum Modulation Factor of 1.0

Screen Modulation Required

Maximum Ratings, Absolute Values

DC Plate Voltage.....	4500 Max	Volts
DC Grid-No. 2 Voltage.....	600 Max	Volts
DC Grid-No. 1 Voltage.....	—120 Max	Volts
DC Plate Current.....	0.80 Max	Amperes
DC Grid-No. 1 Current.....	0.120 Max	Amperes
Plate Input.....	3.60 Max	Kilowatts
Grid-No. 2 Input.....	25 Max	Watts
Plate Dissipation.....	3000 Max	Watts

Typical Operation, Grounded-Grid Circuit

DC Plate Voltage.....	4000	Volts
DC Grid-No. 2 Voltage.....	500	Volts
DC Grid-No. 1 Voltage.....	—80	Volts
Peak RF Plate Voltage.....	2500	Volts
Peak RF Grid-No. 1 Voltage.....	100	Volts
DC Plate Current.....	0.570	Amperes
DC Grid-No. 2 Current.....	0.020	Amperes
DC Grid-No. 1 Current, approximate.....	0.110	Amperes
Driving Power at the Tube, approximate.....	100	Watts
Power Output¶.....	1250	Watts
Cathode Bombarding Voltage.....	540	Volts
Cathode Bombarding Current.....	0.220	Amperes

TECHNICAL INFORMATION (CONT'D)

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

Key-Down Conditions Per Tube Without Amplitude Modulation

Maximum Ratings, Absolute Values

DC Plate Voltage.....	6000 Max	Volts
DC Grid-No. 2 Voltage.....	600 Max	Volts
DC Plate Current.....	1.0 Max	Amperes
Plate Input.....	.5 Max	Kilowatts
Grid-No. 2 Input.....	.40 Max	Watts
Plate Dissipation.....	3.0 Max	Kilowatts
DC Grid-No. 1 Voltage.....	120 Max	Volts
DC Grid-No. 1 Current.....	0.120 Max	Amperes

Typical Operation—Grounded-Grid Circuit up to 900 Megacycles

DC Plate Voltage.....	4500	Volts
DC Grid-No. 2 Voltage.....	550	Volts
DC Grid-No. 1 Voltage.....	-120	Volts
Peak RF Plate Voltage, approximate.....	3000	Volts
Peak RF Grid-No. 1 Voltage.....	140	Volts
DC Plate Current.....	0.6	Amperes
DC Grid-No. 2 Current.....	0.015	Amperes
DC Grid-No. 1 Current.....	0.060	Amperes
Driving Power at Tube, approximate.....	90	Watts
Power Output, approximate¶.....	1500	Watts

* The cathode of the GL6182, because of transit-time effects which raise the temperature of the cathode, is subjected to considerable back bombardment in ultra-high-frequency service. The amount of heating due to bombardment is a function of the operating conditions and frequency, and must be compensated for by a reduction of the cathode power input to prevent over-heating of the cathode with resulting short life. In any case it is important from a tube life standpoint to keep the bombarder power at as low a level as possible consistent with required performance. Bombarder power should be monitored by suitable wattmeter or d-c voltmeter and milliammeter arrangement. For long life, the GL-6182 should be put in operation with about 150 watts bombarding power. After the circuit has been adjusted for proper tube operation, bombarding voltage should be reduced to a value slightly above that at which circuit performance is affected. At a frequency of 900 megacycles and with typical operating conditions the bombarding power can be reduced to approximately 115 watts. At lower frequencies, the reduction will be less. Minor circuit readjustment may be necessary after the above adjustment. The procedure for determining proper bombarder power should be repeated periodically.

† Represents maximum usable cathode current (plate current plus current to each grid) for any condition of operation.

‡ Measured with complete external shielding between cathode and anode.

§ Output capacitance measured between anode and screen grid. Control grid connected directly to screen grid.

¶ Useful power output including power transferred from driver stage. Output circuit efficiency approximately 80 percent.

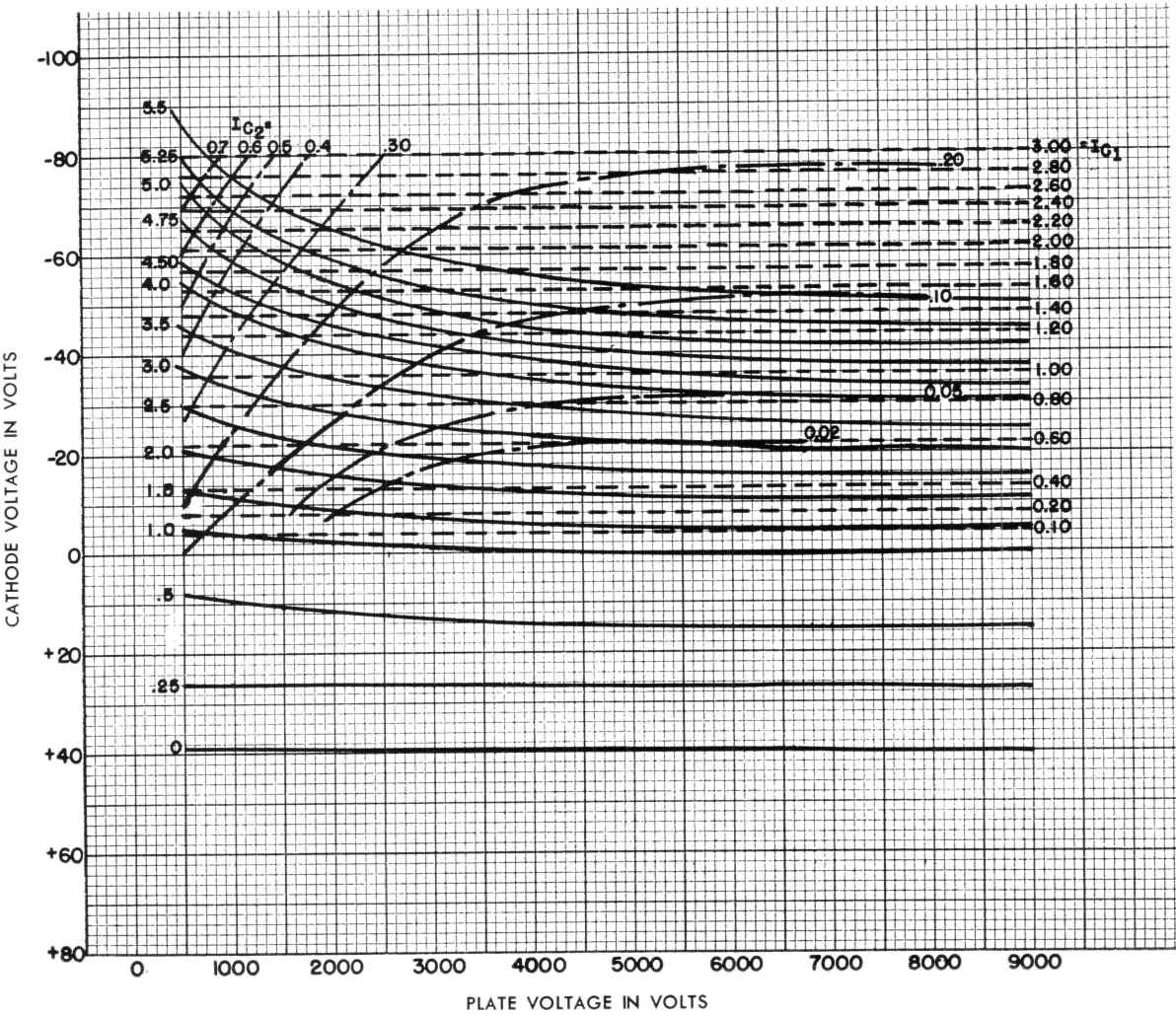
◆ Pressure drop excludes drop through external connections.

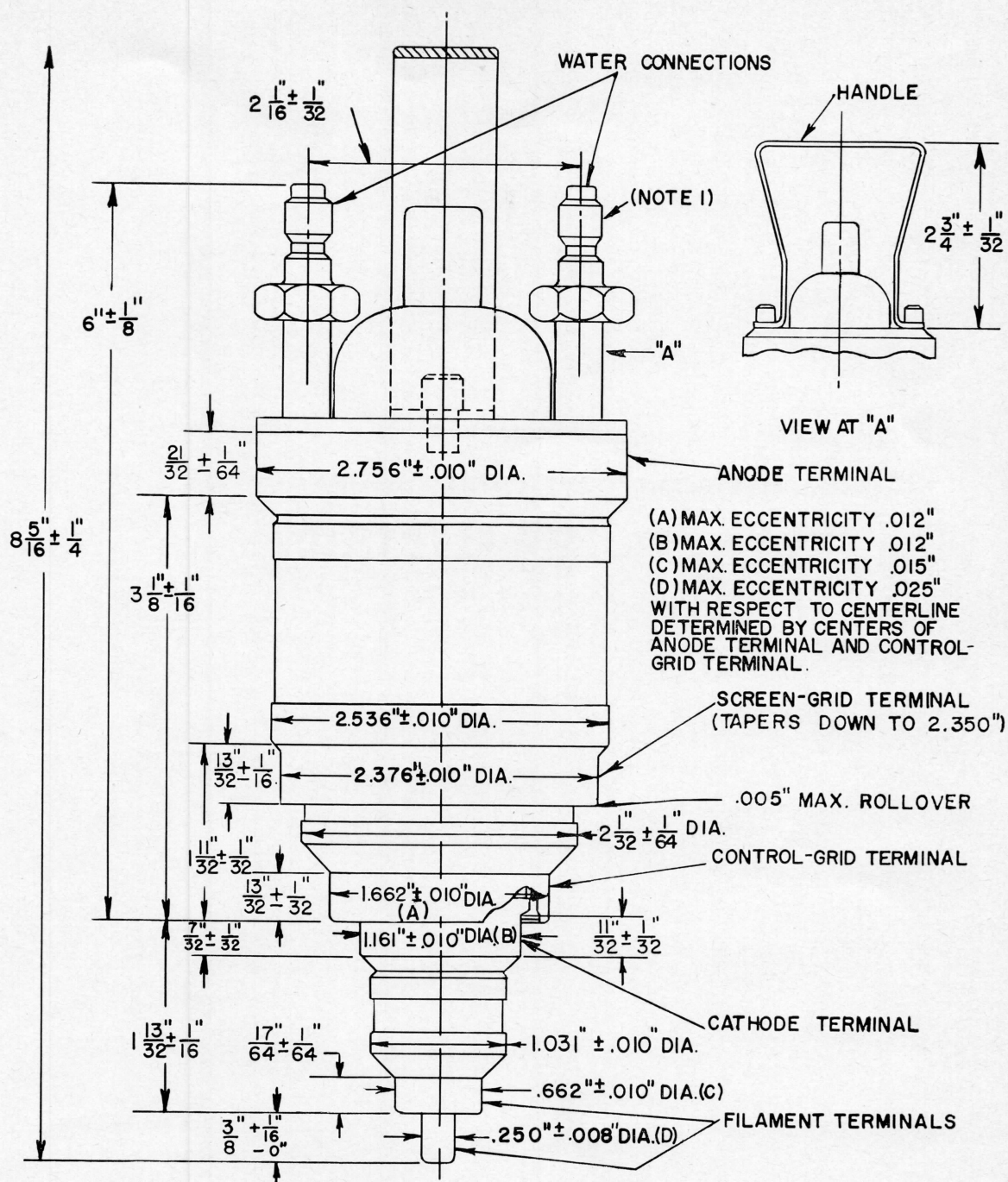
□ Denotes an addition.

⊕ Denotes a change.

CONSTANT CURRENT CHARACTERISTICS

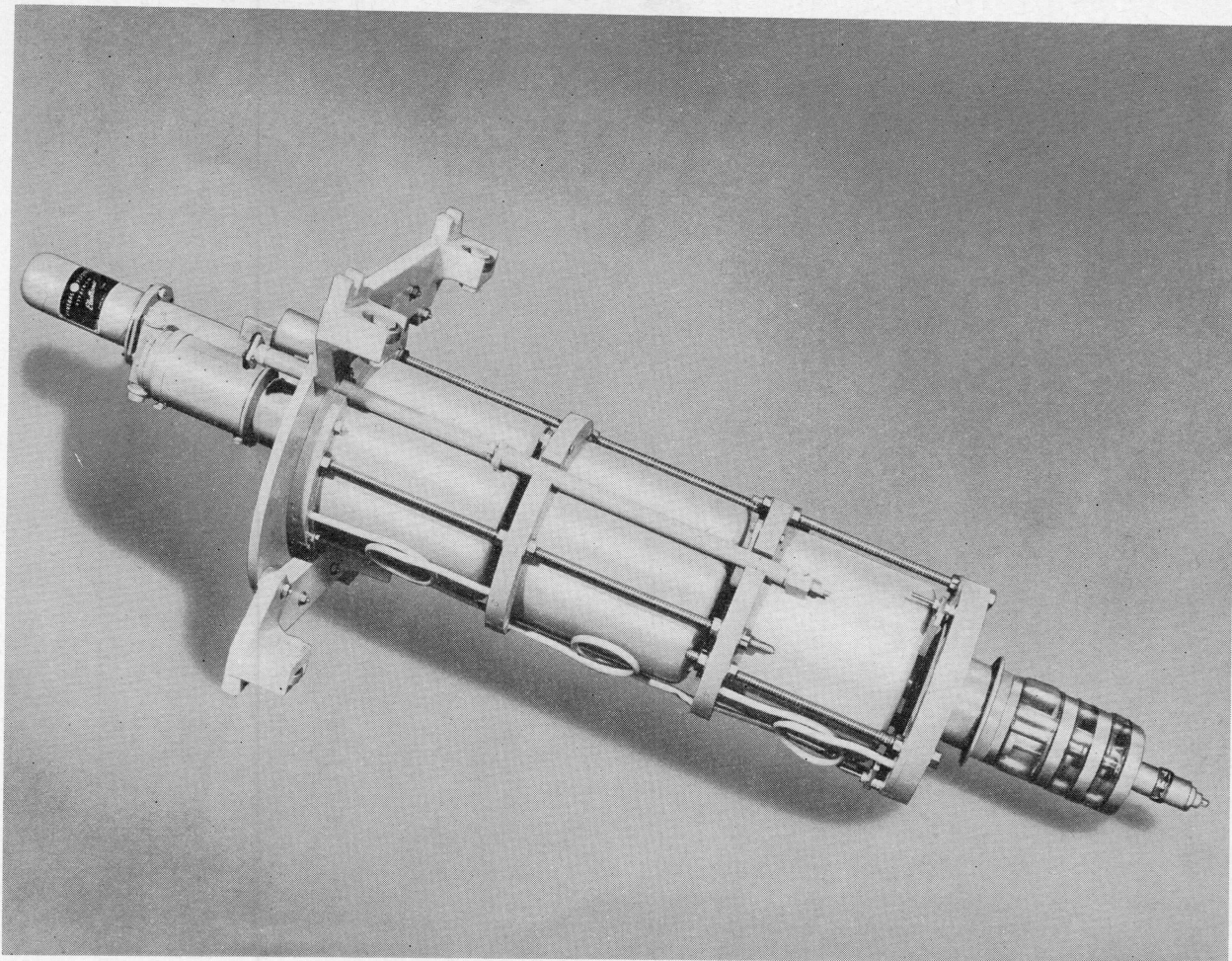
SCREEN VOLTAGE = 500 VOLTS





NOTE 1. TOP PORTION SAME AS TOP PORTION OF HANSEN B2T16.
MATES WITH HANSEN 2-S17 SOCKET OR EQUIVALENT.
HANSEN MANUFACTURING COMPANY CLEVELAND, OHIO

ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
Schenectady 5, N. Y.



KLYSTRON

12-KILOWATT UHF TELEVISION OUTPUT VISUAL-AMPLIFIER SERVICE BROADBAND OPERATION

These tubes are three-resonator tunable klystrons for use as radio-frequency amplifiers. They cover the UHF television band, 470 to 890 megacycles, and each type will provide 12 kilowatts of power output at synchronizing peak level with a minimum power gain of 200 in broadband visual-amplifier service. Broadband operation is obtained by tuning the input and output resonators to the visual carrier frequency and detuning the center resonator

WATER- AND FORCED-AIR-COOLED ELECTROMAGNETIC FOCUSING GAIN IN EXCESS OF 200

above visual carrier by an amount sufficient to give the desired breadth of response.

The tubes have unipotential tantalum disk-type cathodes heated by bombardment, collectors capable of dissipating 51 kilowatts, and require electromagnetic focusing of the electron beam. The cathode seals and the output seals are forced-air cooled; the drift tubes and the collectors are water-cooled. There are two basic resonator diameters for the six types.

Tube Type	Frequency Range Megacycles	Television Channel Coverage
GL-6237	470-530	14-23
GL-6238	530-584	24-32
GL-6239	584-656	33-44
GL-6240	656-722	45-55
GL-6241	722-806	56-69
GL-6242	806-890	70-83

GENERAL  ELECTRIC

Supersedes ET-T1116 dated 10-55

TECHNICAL INFORMATION

GENERAL

Electrical	Bogey	Maximum	
Heater Voltage*	5.5	....	Volts
Heater Starting Voltage	.8	....	Volts
Heater Current at 5.5 Volts	.35	....	Amperes
Heater Current at 8 Volts	.55	....	Amperes
Heater Starting Current		100	Amperes
Heater Cold Resistance	0.017	....	Ohms
Cathode Bombarder Voltage		3	Kilovolts
Cathode Bombarder Current		550	Milliamperes
Cathode Bombarder Input†		1500	Watts
Cathode Heating Time‡	3	....	Minutes
Magnetic Field, approximate range§	300 to 500	....	Gausses
Mechanical			
Mounting Position—Vertical, Collector End up			
Water Flow			
Collector	15	Min	Gallons per Minute
Pressure Drop at Rated Flow, approximate	.65		Pounds per Square Inch
Drift Tubes	2	Min	Gallons per Minute
Pressure Drop at Rated Flow, approximate	.65		Pounds per Square Inch
Water Pressure	.80	Max	Pounds per Square Inch
Outlet Water Temperature	.70	Max	C
Air Flow			
Cathode and Heater Seals	300	Min	Cubic Feet per Minute
Output Seals	15	Min	Cubic Feet per Minute
Glass Temperature	150	Max	C
Maximum Over-All Length, approximate	4½ to 5		Feet
Maximum Over-All Diameter	21½		Inches
Net Weight, approximate//	180 to 280		Pounds

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

RADIO-FREQUENCY AMPLIFIER—BROADBAND TELEVISION SERVICE

Synchronizing-Level Conditions Per Tube Unless Otherwise Specified

Maximum Ratings, Absolute Values

DC Beam Voltage	18	Max	Kilovolts
DC Beam Current π	3	Max	Amperes
Beam Input	51	Max	Kilowatts
Collector Dissipation	51	Max	Kilowatts
Drift Tube Collection Current	250	Max	Milliamperes
Driving Power	150	Max	Watts

Typical Operation—Bandwidth 6 Megacycles

DC Beam Voltage	17.5	Kilovolts
DC Beam Current π	2.75	Amperes
Driving Power**		
Synchronizing Level	25	Watts
Pedestal Level	12	Watts
Power Output		
Saturation Level Δ	15	Kilowatts
Synchronizing Level	12	Kilowatts
Pedestal Level	6.75	Kilowatts

RADIO-FREQUENCY AMPLIFIER—FREQUENCY MODULATION OR TELEVISION SERVICE

Key-Down Conditions per Tube Without Amplitude Modulation

Maximum Ratings, Absolute Values

DC Beam Voltage	18	Max	Kilovolts
DC Beam Current π	3	Max	Amperes
Beam Input	51	Max	Kilowatts
Collector Dissipation	51	Max	Kilowatts
Drift Tube Collection Current	250	Max	Milliamperes
Driving Power	150	Max	Watts
Power Output	12	Max	Kilowatts

TECHNICAL INFORMATION (CONT'D)

RADIO-FREQUENCY AMPLIFIER—FREQUENCY MODULATION OR TELEVISION SERVICE (CONT'D)

Key-Down Conditions Per Tube Without Amplitude Modulation

Typical Operation

DC Beam Voltage.....	17	14	Kilovolts
DC Beam Current π	2.3	1.8	Amperes
Drift Tube Collection Current.....	150	100	Milliamperes
Driving Power**.....	10	6	Watts
Power Output.....	12	7	Kilowatts

* The bogey value is the approximate value of heater voltage required to furnish just sufficient bombarder current which with a bombarder voltage of 2500 volts maintains the main cathode at an operating temperature adequate to furnish a beam current of 3 amperes. To avoid excessively long cathode-heating time the heater voltage may be started at approximately 8 volts and gradually reduced to the normal operating value as the cathode reaches the proper operating temperature. Automatic regulation of the heater supply is required to maintain stable cathode temperature and beam current. Specific recommendations regarding the regulating circuit will be found in the Installation and Operation Instructions.

† If an unfiltered bombarder supply is used, an appropriate correction factor must be determined and applied to d-c meter readings in computing actual power.

‡ Approximate time required to permit normal operation. Beam voltage may be applied earlier.

§ The magnetic field required will vary with the type and the channel to which the tube is tuned. It ranges between 300 and 500 gauss. Three independently regulated electromagnets around the body assembly and one around the cathode structure are required for proper electron-beam focusing. Details regarding the design and positioning of these magnets will be found in the Installation and Operation Instructions.

// Approximate Weights

GL-6237	280 Pounds
GL-6238	280 Pounds
GL-6239	280 Pounds
GL-6240	180 Pounds
GL-6241	180 Pounds
GL-6242	180 Pounds

π Includes both collector current and drift-tube collection current.

** Approximate driving power required at the input terminals of the klystron. Additional driving power should be provided to take care of circuit losses and any isolating attenuation used between driver and klystron.

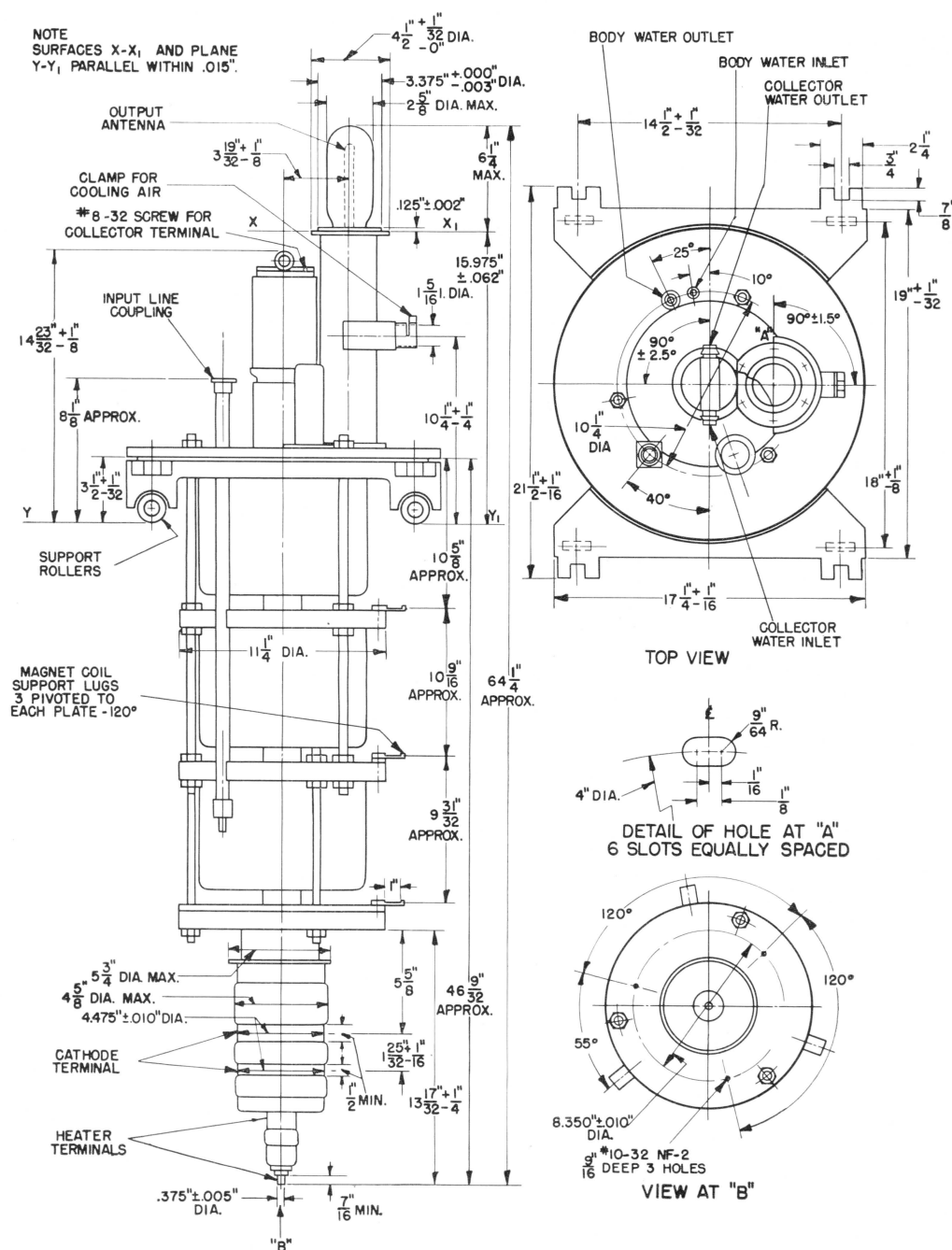
△ Saturation power level is the maximum radio-frequency power level which the tube will deliver for a given beam input power. Under operating conditions for a 15-kilowatt saturation level, the power-output versus driving-power characteristic is linear enough to permit application in video television up to a 12-kilowatt synchronizing peak level with a moderate amount of synchronizing peak pre-emphasis in the driver stage.

GL-6237-GL-6242

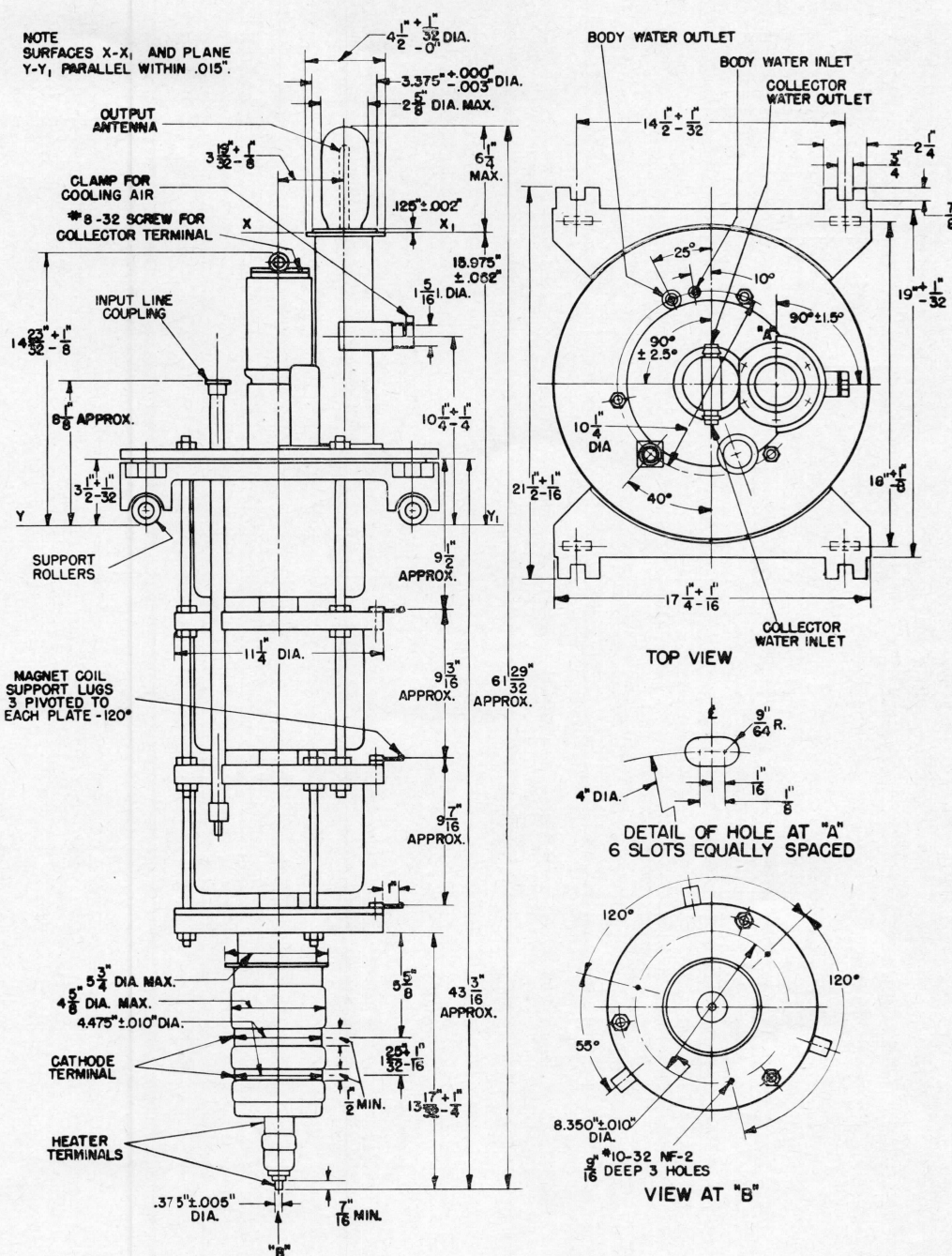
ET-T1116A

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OUTLINE GL-6237



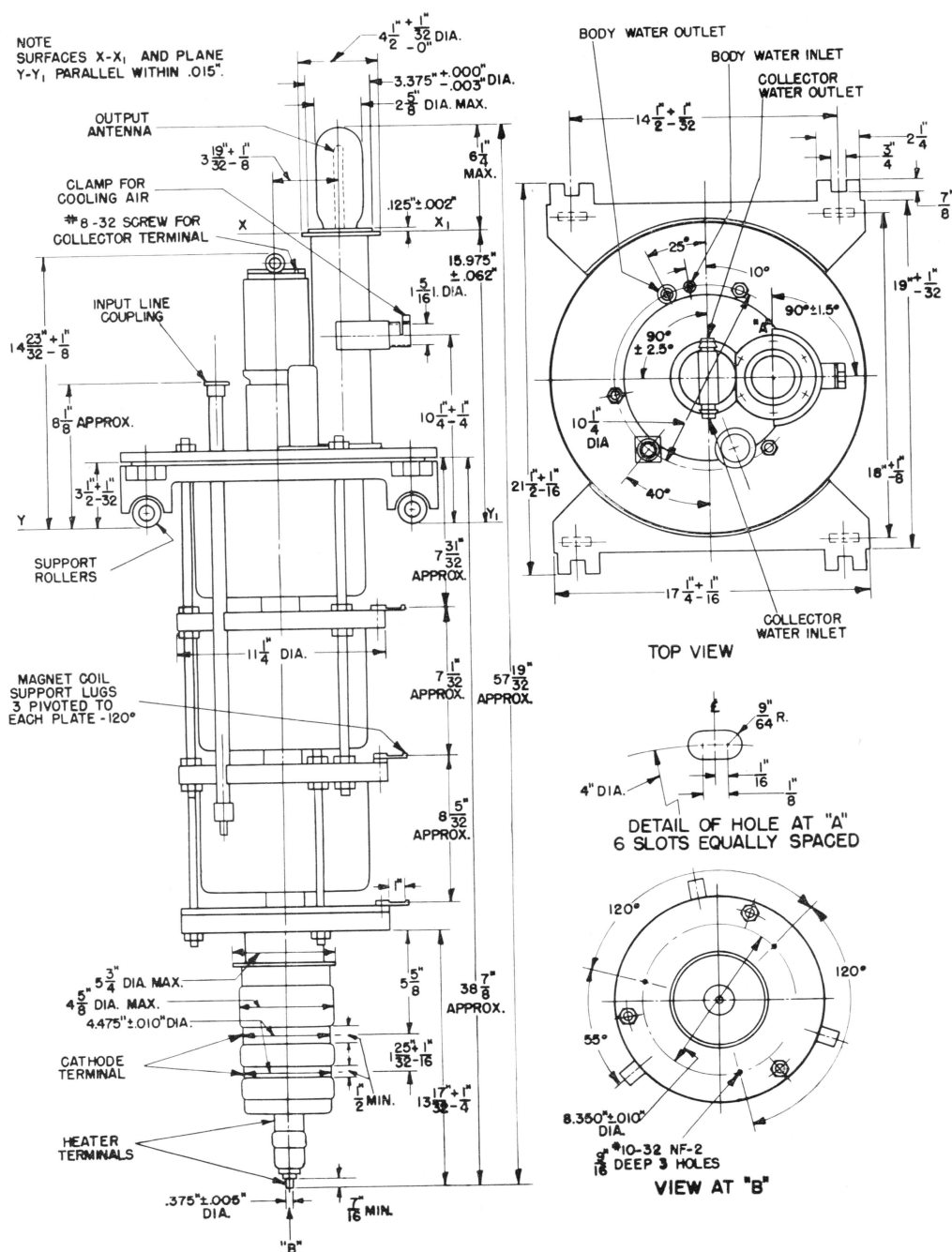
OUTLINE GL-6238

GL-6237-GL-6242

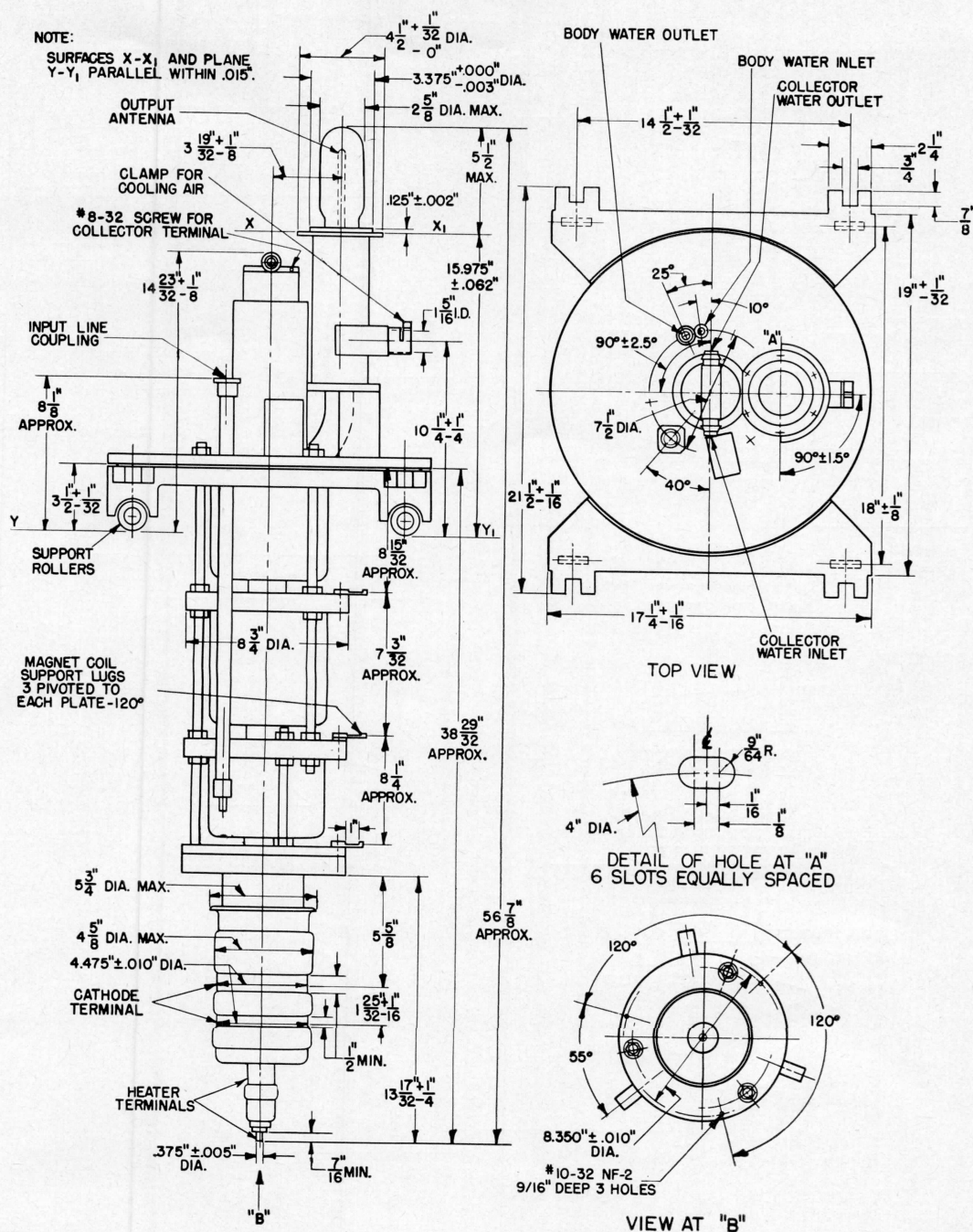
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OUTLINE GL-6239



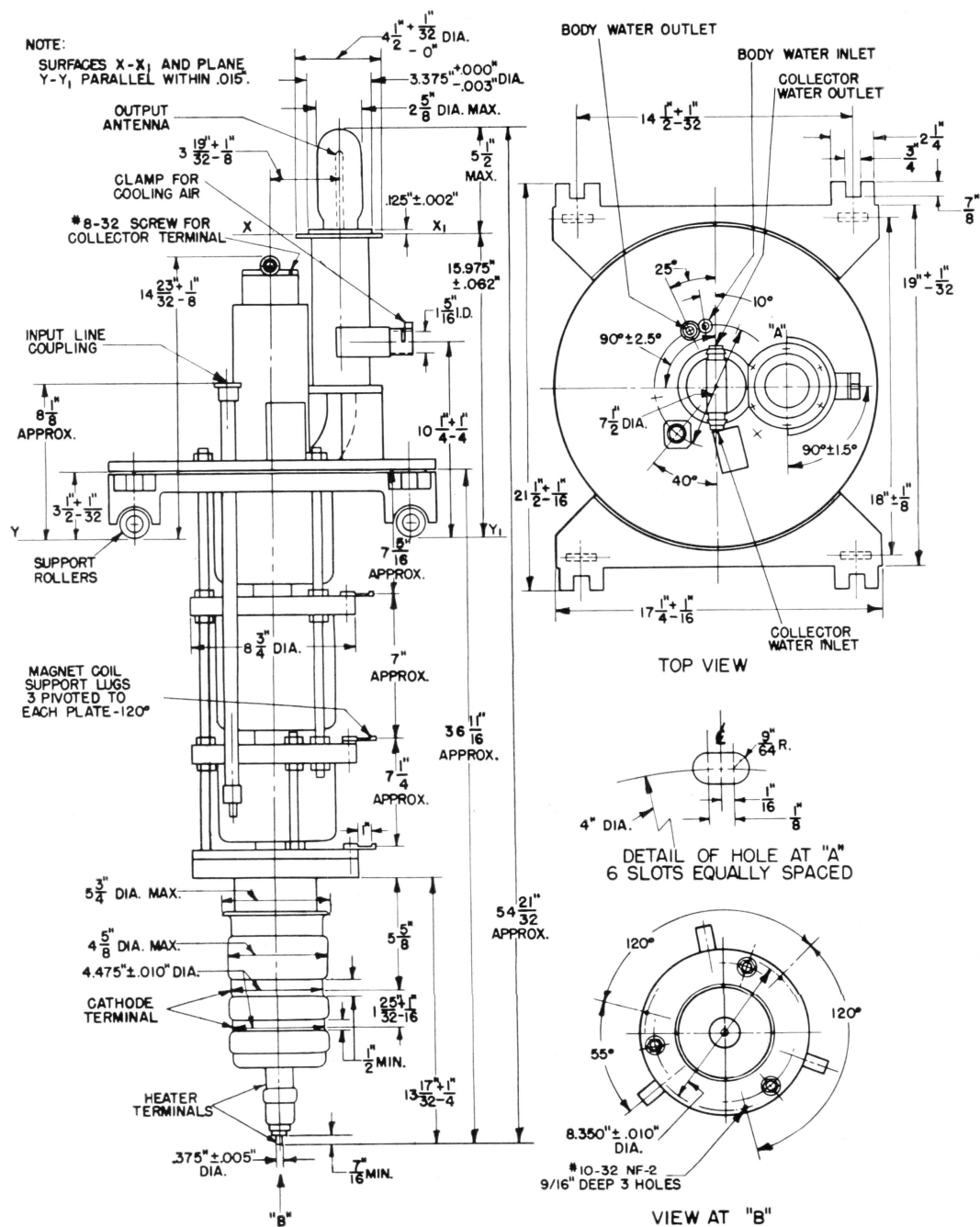
OUTLINE GL-6240

GL-6237-GL-6242

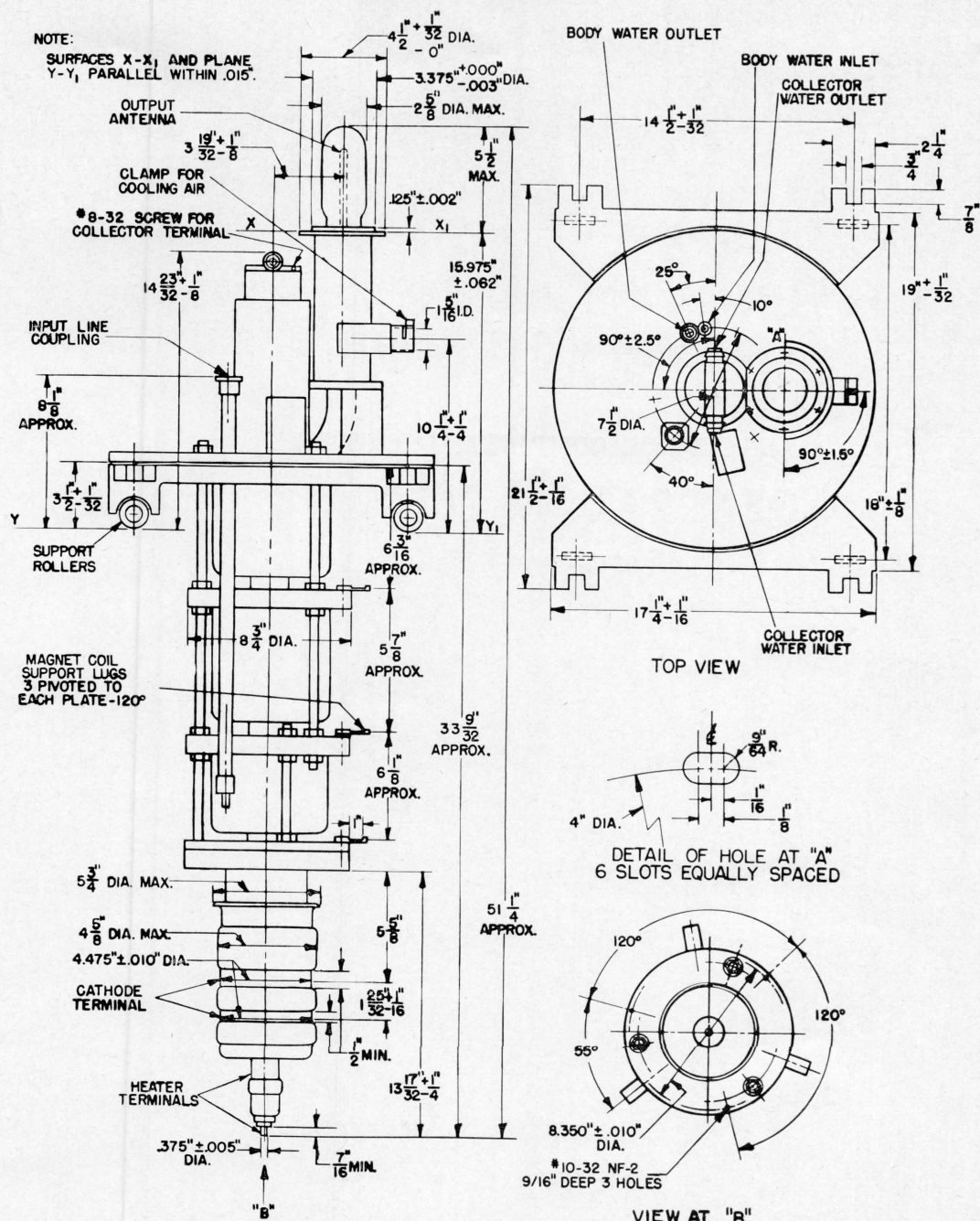
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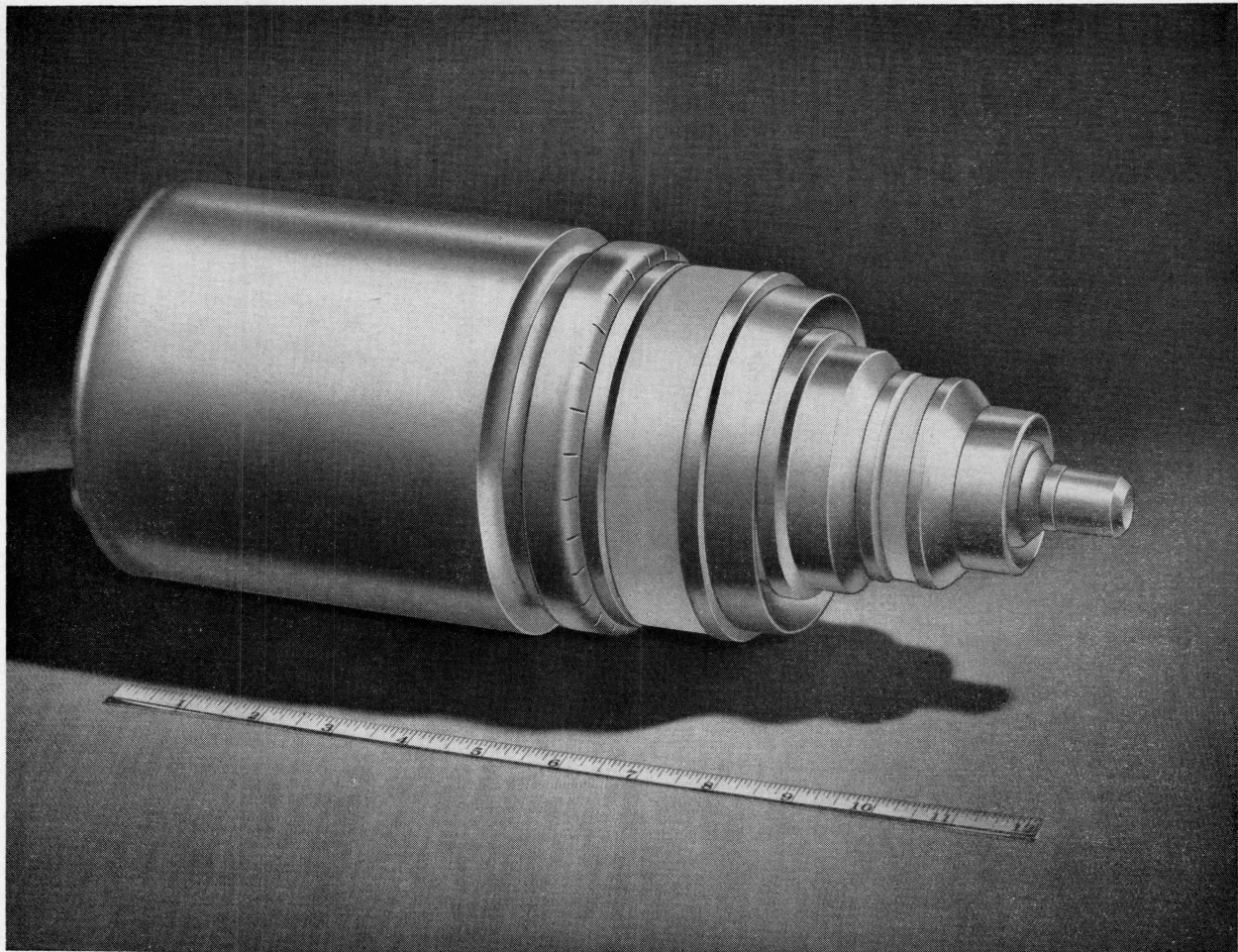


OUTLINE GL-6241



OUTLINE GL-6242

ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
Schenectady 5, N. Y.



TETRODE

**25-KILOWATTS VHF TELEVISION OUTPUT
VHF TETRODE
GROUNDED-GRID CIRCUITS**

**WATER COOLED
METAL AND CERAMIC
GAIN IN EXCESS OF 10**

The GL-6251 is a four-electrode, water-and-forced-air-cooled transmitting tube for use as a power amplifier or oscillator in grounded-grid circuits with both grids maintained at radio-frequency ground potential. The output circuit is connected between the anode and the screen grid. The anode is capable of dissipating twenty-five kilowatts. The cathode is a thoriated-tungsten filament. Maximum ratings apply up to 220 megacycles.

In Class B grounded-grid broadband television amplifier service this tube has a useful synchroniz-

ing peak-power output of twenty-five kilowatts at 220 megacycles. Because of its ratings, the tube is also well adapted to use in dielectric-heating equipment.

High operating efficiency is assured because of the close spacing of the tube electrodes, the ring-seal construction, and the low-loss factor due to the silver-plated external parts and the ceramic insulator. The ring-seal design permits quick plug-in installation. In addition, the grounded-grid construction eliminates the necessity for neutralization in a properly designed circuit.

GENERAL  ELECTRIC

Supersedes ET-T1165 dated 12-54

TECHNICAL INFORMATION

GENERAL

Electrical

	Minimum	Bogey	Maximum
⊕ Filament Voltage.....	5.1	5.5	5.75 Volts
Filament Current at 5.5 Volts.....		190	 Amperes
Filament Starting Current.....			360 Amperes
Filament Cold Resistance.....		0.004	 Ohms
Filament Heating Time.....	30		 Seconds
Amplification Factor, G_2 to G_1			
$E_b = 1000$ Volts, $I_b = 0.1$ Amperes.....		20	....
Peak Cathode Current*.....			30 Amperes
Direct Interelectrode Capacitances§			
Grounded-Grid Circuit			
Cathode-Plate†.....		0.06	 $\mu\mu f$
Input.....		75	 $\mu\mu f$
Output.....		27	 $\mu\mu f$

Mechanical

Mounting Position—Vertical, anode down		
Net Weight, approximate.....	15	Pounds

Thermal

Type of Cooling—Water and Forced Air		
Water Cooling		
Water Flow		
Anode.....	12 Min	Gallons per Minute
Water Pressure.....	80 Max	Pounds per Square Inch
Pressure Drop at Rated Flow, approximate.....	13	Pounds per Square Inch
Outlet Water Temperature.....	70 Max	C
Air Cooling		
Air Flow		
Anode Seal.....	30 Min	Cubic Feet per Minute
Filament Seal.....	15 Min	Cubic Feet per Minute
Grid-to-Grid Seal.....	10 Min	Cubic Feet per Minute
Ceramic Temperature.....	200 Max	C
□ Seal and Terminal Temperature.....	180 Max	C

MAXIMUM RATINGS AND TYPICAL OPERATION

RADIO-FREQUENCY AMPLIFIER—CLASS B TELEVISION SERVICE

Synchronizing-Level Conditions Per Tube Unless Otherwise Specified

Maximum Ratings, Absolute Values

DC Plate Voltage.....	7000 Max	Volts
⊕ DC Grid-No. 2 Voltage.....	700 Max	Volts
DC Plate Current.....	8 Max	Amperes
Plate Input.....	50 Max	Kilowatts
Grid-No. 2 Input‡.....	350 Max	Watts
⊕ DC Grid-No. 2 Current		
Pedestal Level.....	0.200 Max	Amperes
Plate Dissipation.....	25 Max	Kilowatts
Grid-No. 1 Dissipation.....	150 Max	Watts
⊕ DC Grid-No. 1 Current.....	1.0 Max	Amperes

Typical Operation—Grounded-Grid Circuit up to 216 Megacycles

Bandwidth 7 Megacycles, 1 Decibel Voltage		
DC Plate Voltage.....	6800	Volts
⊕ DC Grid-No. 2 Voltage//.....	600	Volts
DC Grid-No. 1 Voltage.....	— 20	Volts
Peak RF Plate Voltage		
Synchronizing Level.....	4800	Volts
Pedestal Level.....	3600	Volts
Peak RF Driving Voltage		
Synchronizing Level.....	350	Volts
Pedestal Level.....	250	Volts

TECHNICAL INFORMATION (CONT'D)

Typical Operation (Cont'd)

DC Plate Current		
Synchronizing Level.....	7.5	Amperes
Pedestal Level.....	5.8	Amperes
DC Grid-No. 2 Current//		
Pedestal Level.....	0.05	Amperes
DC Grid-No. 1 Current		
Synchronizing Level.....	0.90	Amperes
Pedestal Level.....	0.55	Amperes
Driving Power at Tube, approximate		
Synchronizing Level.....	2.3	Kilowatts
Pedestal Level.....	1.3	Kilowatts
Power Output, approximate¶		
Synchronizing Level.....	.25	Kilowatts
Pedestal Level.....	.15	Kilowatts

* Maximum usable cathode current (plate current plus current to each grid) for any condition of operation.

§ Control grid and screened grid are connected together.

† Measured with 12-inch diameter flat metal disk attached to the screen-grid terminal and grounded.

‡ Calculated from characteristic curve only. This value includes dissipation transferred from driving power. Maximum allowable screen input as indicated by measured d-c current and voltage is much lower because of secondary screen emission.

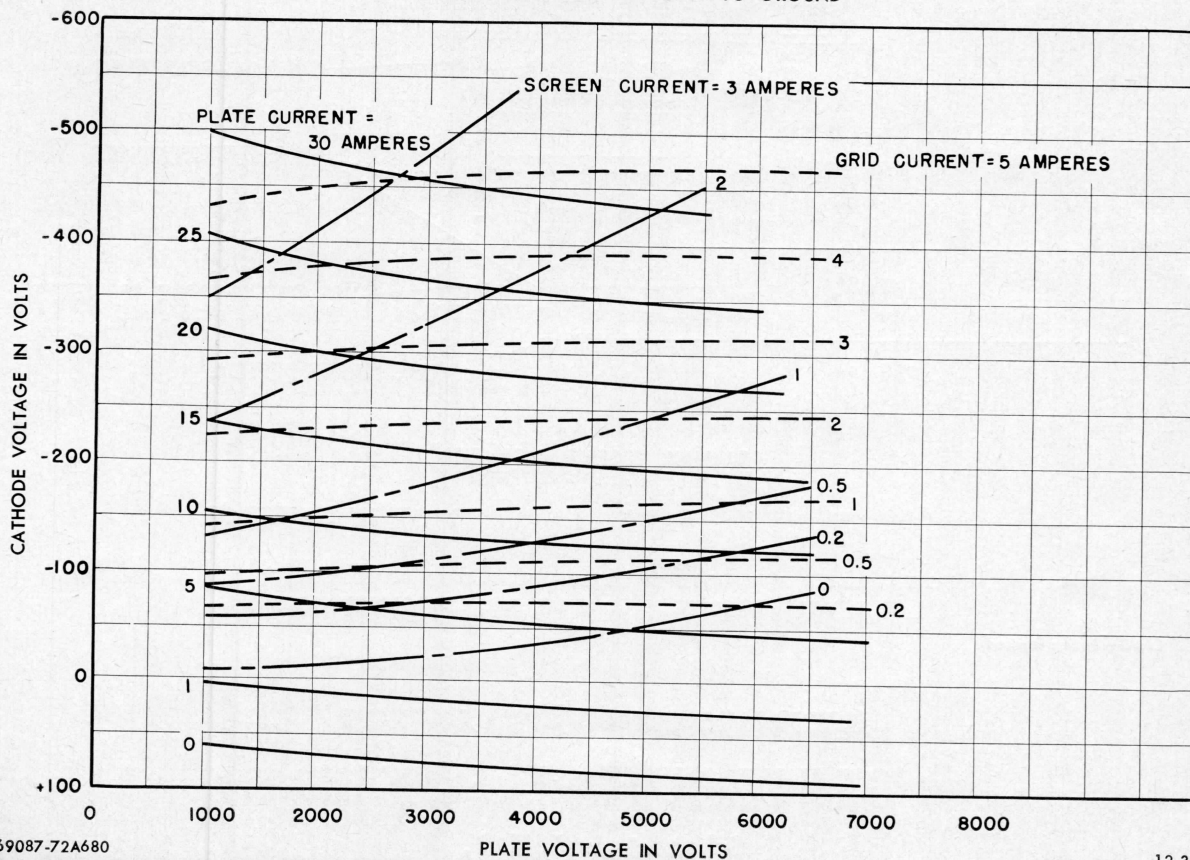
//DC Grid-No. 2 voltage and current should be held at the minimum values consistent with proper circuit operation. Negative values of screen current are frequently encountered but are not detrimental.

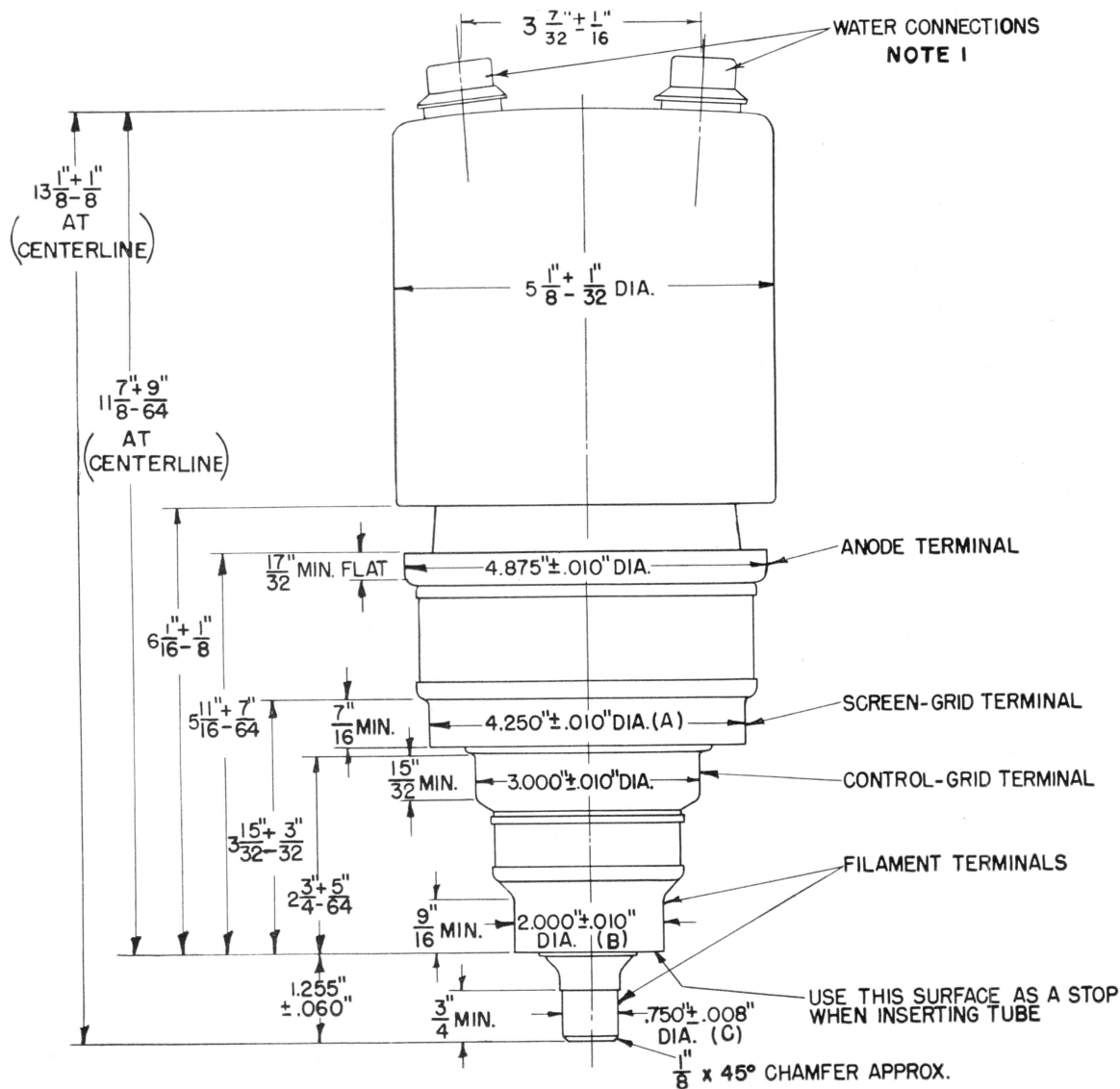
¶ Useful power output including power transferred from driver stage.

⊕ Denotes a change.

□ Denotes an addition.

CONSTANT CURRENT CHARACTERISTICS
SCREEN VOLTAGE=700 VOLTS, CONTROL-GRID GROUNDED
ELECTRODE VOLTAGES MEASURED TO GROUND





(A) MAX. ECCENTRICITY .040"
 (B) MAX. ECCENTRICITY .040"
 (C) MAX. ECCENTRICITY .050"
 WITH RESPECT TO CENTERLINE DETERMINED BY CENTERS OF
 ANODE TERMINAL & CONTROL-GRID TERMINAL.

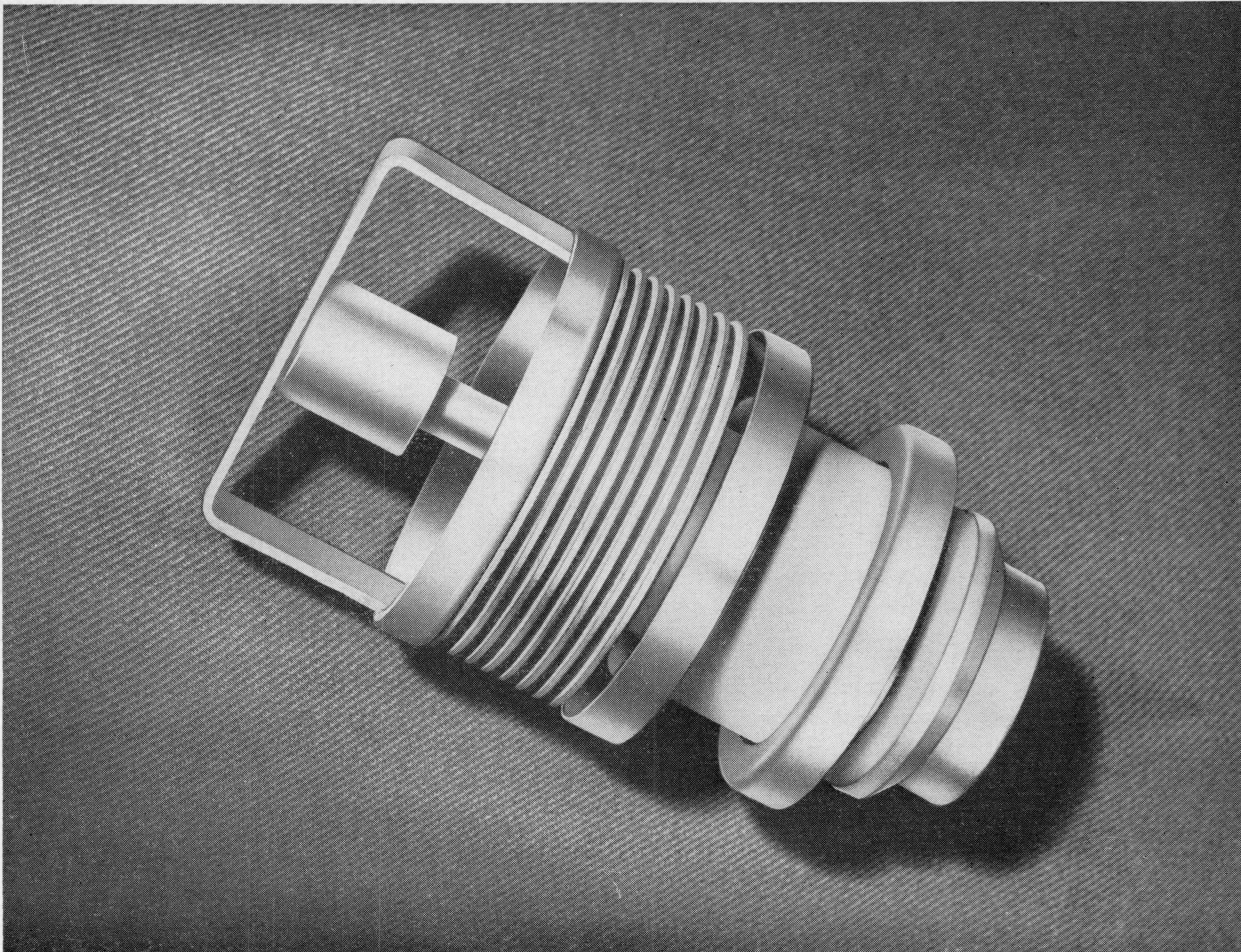
NOTE 1: MATES WITH WIGGINS SOCKET NO. BC-323B OR EQUIVALENT.
 E. B. WIGGINS OIL TOOL COMPANY, INC., LOS ANGELES, CALIFORNIA

N-20726AZ—Outline Revised

1-6-59

ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
 Schenectady 5, N. Y.

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TETRODE

**250-WATT UHF TELEVISION OUTPUT
TETRODE
GROUNDED-GRID CIRCUIT**

**FORCED-AIR COOLED
METAL AND CERAMIC
INTEGRAL RADIATOR**

The GL-6283 four-electrode transmitting tube with a metal-and-ceramic envelope is a power amplifier or oscillator designed particularly for use in grounded-grid circuits where both grids are maintained at radio-frequency ground potential. Under such conditions in a tetrode the output circuit is connected between the anode and the screen grid.

The tube has an indirectly heated oxide-coated cathode, a plate dissipation rating of 300 watts,

and is forced-air cooled. Maximum ratings apply at frequencies up to 900 megacycles.

In Class B, grounded-grid, broadband, television-amplifier service the GL-6283 can deliver a useful synchronizing peak power output of 250 watts at the maximum frequency of 900 megacycles. When the tube is used as an amplifier or oscillator in Class C telegraphy narrowband service 150 watts of useful continuous power can be obtained.

TECHNICAL INFORMATION

GENERAL

Electrical	Minimum	Bogey	Maximum
Heater Voltage*	—	6.3	6.8 Volts
Heater Current at Bogey Voltage	—	3.6	— Amperes
Cathode Heating Time	1	—	— Minutes

GENERAL  ELECTRIC

§Supersedes pages 1 thru 4 only dated 6-58

TECHNICAL INFORMATION (CONT'D)

Amplification Factor, G_2 to G_1	Minimum	Bogey	Maximum
$E_{g2} = 250$ Volts, $I_{g2} = 0.050$ Ampere, Plate Floating.....		10	.....
Peak Cathode Current†.....			1.75 Amperes
Direct Interelectrode Capacitances			
Cathode-Plate†.....		0.006	 $\mu\mu f$
Input, G_2 tied to G_1		17.4	 $\mu\mu f$
Output, G_2 tied to G_1 ♦.....		6.4	 $\mu\mu f$

Mechanical

Mounting Position—Any

Air Flow

Through Radiator**

Plate Dissipation.....	300	240	180 Watts
Air Flow.....	20.5	14	7.5 Min Cubic Feet per Minute
Static Pressure.....	0.65	0.38	0.16 Inches Water
Screen-Grid to Control-Grid Seals.....	.....	.....	1 Min Cubic Feet per Minute
Heater to Cathode Seals.....	.....	.....	1 Min Cubic Feet per Minute
Incoming Air Temperature.....	.....	.....	45 Max C
Radiator Hub Temperature at Point Adjacent to Anode	.....	.....	.....
Seal.....	.....	.....	180 Max C
Ceramic Temperature at any Point.....	.....	.....	200 Max C
Net Weight, approximate.....	.....	.....	1.0 Pounds

Forced-air cooling to be applied before and during the application of any voltages.

**Provision must be made for unobstructed passage of cooling air between radiator fins and between the anode terminal and adjacent radiator fin.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

□ RADIO-FREQUENCY POWER AMPLIFIER—CLASS B LINEAR

Carrier Conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

DC Plate Voltage.....	2000 Max	Volts
DC Grid-No. 2 Voltage.....	320 Max	Volts
DC Plate Current.....	0.250 Max	Amperes
Plate Input.....	475 Max	Watts
Grid-No. 2 Input.....	5 Max	Watts
Plate Dissipation.....	300 Max	Watts

Typical Operation—Grounded-Grid Circuit at 225–400 Megacycles

DC Plate Voltage.....	1750	Volts
DC Grid-No. 2 Voltage.....	250	Volts
DC Grid-No. 1 Voltage, approximate.....	—20	Volts
#Peak RF Plate Voltage, approximate.....	1250	Volts
#Peak RF Grid-No. 1 Voltage, approximate.....	40	Volts
DC Plate Current.....	0.200	Amperes
Zero Signal DC Plate Current, $E_b = 1750$ V, $E_{c2} = 250$ V, E_{c1} adjusted for $I_b = 20$ ma.....	0.020	Amperes
DC Grid-No. 2 Current.....	0.005	Amperes
DC Grid-No. 1 Current.....	0.010	Amperes
#Driving Power, approximate.....	20	Watts
♥Power Output.....	110	Watts

RADIO-FREQUENCY AMPLIFIER—CLASS B TELEVISION SERVICE

Synchronizing-Level Conditions Per Tube Unless Otherwise Specified

Maximum Ratings, Absolute Values

DC Plate Voltage.....	1600 Max	Volts
DC Grid-No. 2 Voltage.....	320 Max	Volts
DC Plate Current.....	0.400 Max	Amperes
Plate Input.....	600 Max	Watts
Grid-No. 2 Input.....	15 Max	Watts
Plate Dissipation.....	300 Max	Watts
Grid-No. 1 Dissipation.....	2 Max	Watts

Typical Operation—Grounded-Grid Circuit up to 900 Megacycles

Bandwidth 6 Megacycles

DC Plate Voltage.....	1500	Volts
DC Grid-No. 2 Voltage.....	250	Volts
DC Grid-No. 1 Voltage.....	—25	Volts

TECHNICAL INFORMATION (CONT'D)

Peak RF Plate Voltage		
Synchronizing Level.....	1100	Volts
Pedestal Level.....	825	Volts
Peak RF Driving Voltage		
Synchronizing Level.....	35	Volts
Pedestal Level.....	27	Volts
DC Plate Current		
Synchronizing Level.....	0.400	Amperes
Pedestal Level.....	0.295	Amperes
DC Grid-No. 2 Current (Pedestal Level).....	0.007	Amperes
DC Grid-No. 1 Current		
Synchronizing Level.....	0.036	Amperes
Pedestal Level.....	0.016	Amperes
Driving Power at Tube, approximate		
Synchronizing Level.....	25	Watts
Pedestal Level.....	15	Watts
Power Output, approximate		
Synchronizing Level†.....	260	Watts
Pedestal Level‡.....	145	Watts

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

Key-Down Conditions Per Tube Without Amplitude Modulation△

Maximum Ratings, Absolute Values

DC Plate Voltage.....	1600 Max	Volts
DC Grid-No. 2 Voltage.....	320 Max	Volts
DC Grid-No. 1 Voltage.....	—100 Max	Volts
DC Plate Current.....	0.300 Max	Amperes
DC Grid-No. 1 Current.....	0.050 Max	Amperes
Plate Input.....	450 Max	Watts
Grid-No. 2 Input.....	15 Max	Watts
Plate Dissipation.....	300 Max	Watts
Grid-No. 1 Dissipation.....	2 Max	Watts

Typical Operation—Grounded-Grid Circuit at 900 Megacycles

DC Plate Voltage.....	1500	Volts
DC Grid-No. 2 Voltage.....	250	Volts
DC Grid-No. 1 Voltage.....	—40	Volts
Peak RF Plate Voltage, approximate.....	1000	Volts
Peak RF Grid-No. 1 Voltage, approximate.....	55	Volts
DC Plate Current.....	0.290	Amperes
DC Grid-No. 2 Current, approximate.....	0.010	Amperes
DC Grid-No. 1 Current, approximate.....	—0.020	Amperes
Driving Power, approximate.....	12	Watts
Power Output, approximate¶.....	154	Watts

* The cathode of the GL-6283, because of transit-time effects which raise the temperature of the cathode, is subjected to considerable back bombardment in ultra-high-frequency service. The amount of heating due to bombardment is a function of the operating conditions and frequency and must be compensated for by a reduction of the heater input to prevent overheating of the cathode with resulting short life. For long life, the GL-6283 should be put in operation with rated heater voltage. After the circuit has been adjusted for proper tube operation the heater voltage should be reduced to a value about one-half volt above that at which circuit performance is affected. In any case it is important from a tube life standpoint to keep the GL-6283 filament voltage at as low a level as possible consistent with required performance. However, the filament voltage should not be reduced below 5.5 volts. At a frequency of 900 megacycles with typical operating conditions the heater voltage can be reduced to approximately 5.5 volts. Minor circuit readjustment may be necessary after the above adjustment.

† Represents maximum usable cathode current (plate current plus current to each grid) for any condition of operation.

‡ Measured with a 6-inch minimum diameter flat metal disk attached to the screen-grid ring. Control grid connected to the screen grid.

♦ Output capacitances measured between anode and screen grid. Control grid connected directly to screen grid.

#Measured at the crest of the audio-frequency cycle with a modulation factor of 1.0.

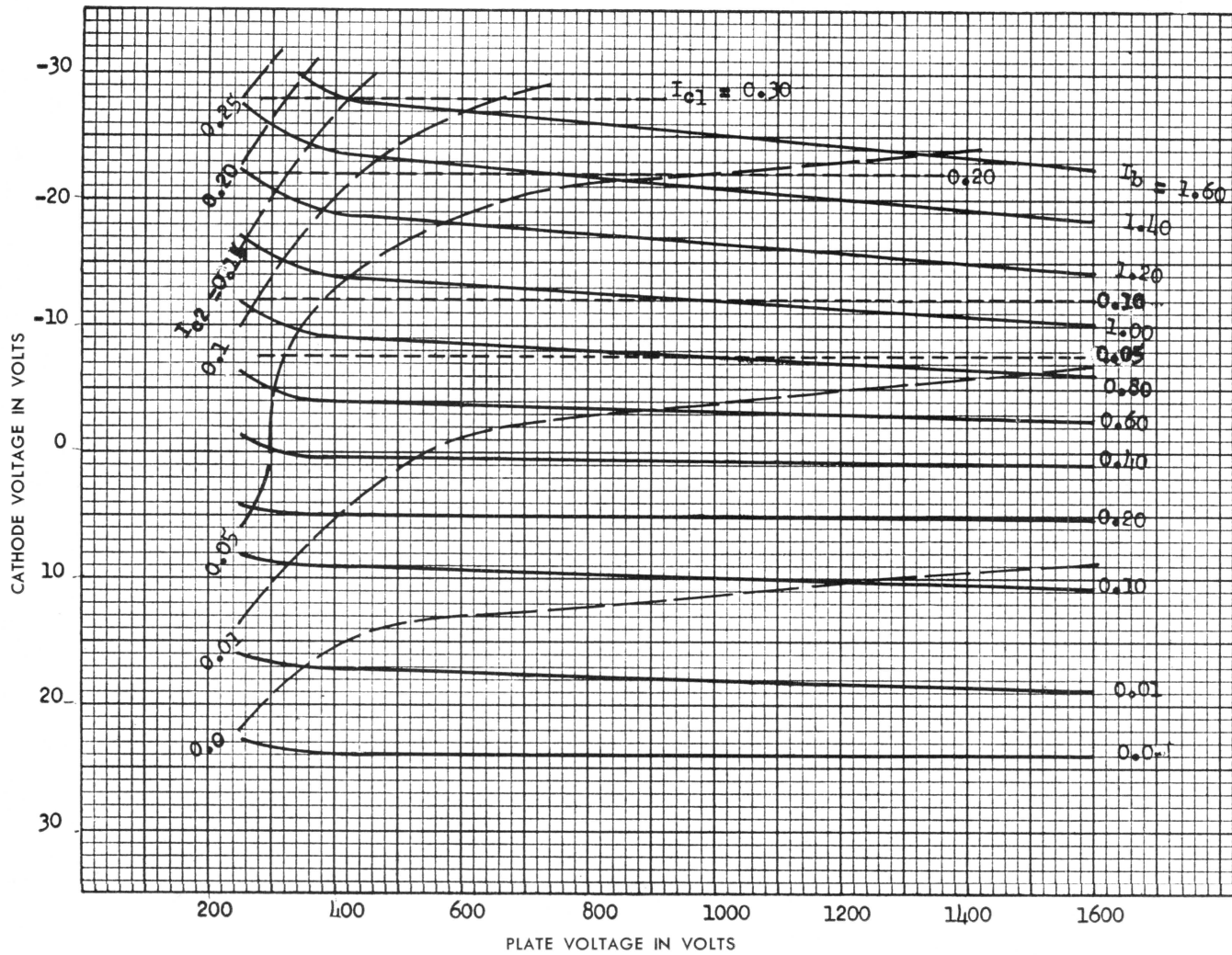
♥ Useful power output as measured in output-circuit load.

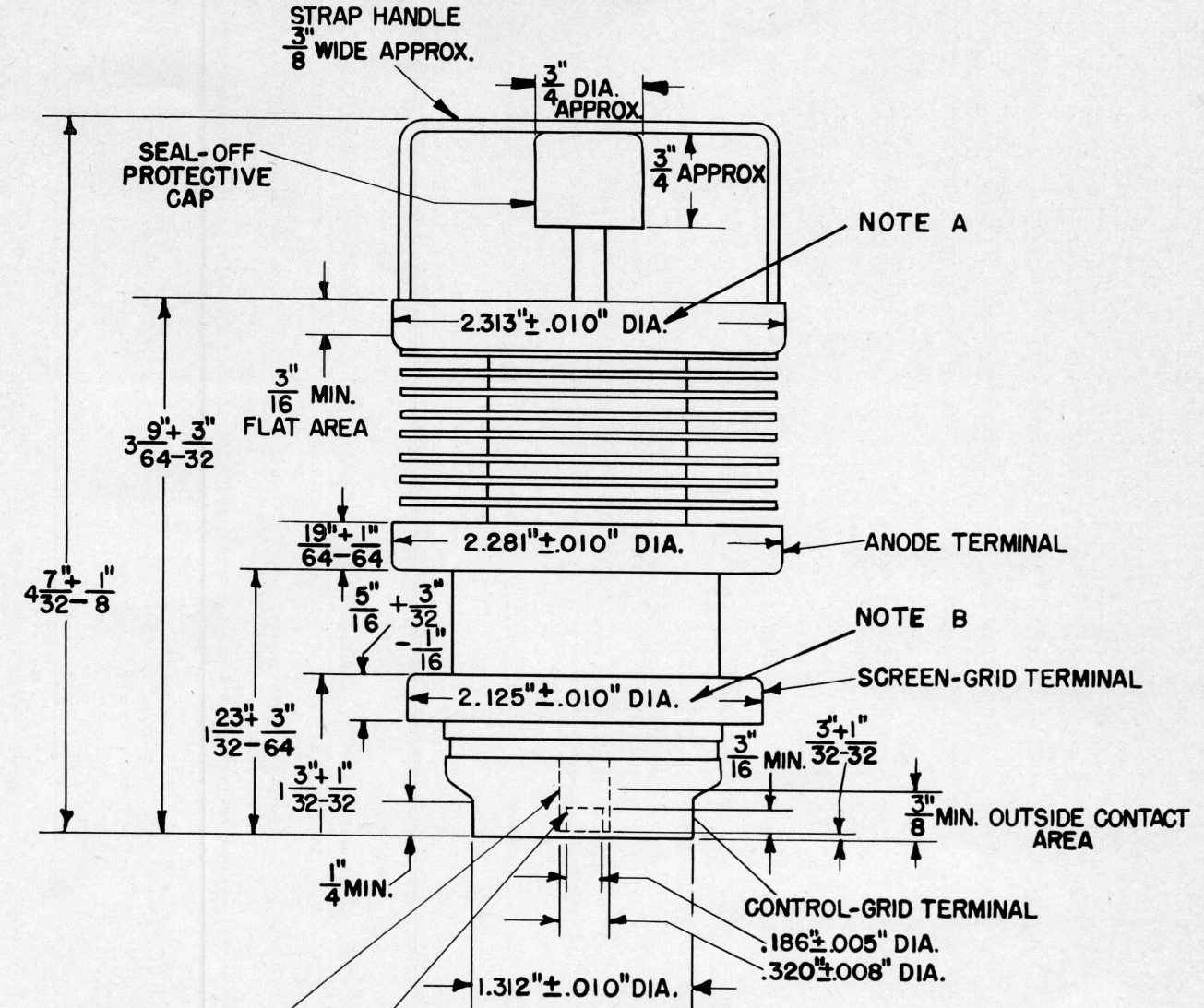
¶ Useful power output including power transferred from driver stage. Output circuit efficiency approximately 80 percent.

△ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 percent of the carrier conditions.

□ Denotes an addition.

CONSTANT-CURRENT CHARACTERISTIC
SCREEN VOLTAGE = 250 VOLTS, CONTROL GRID GROUNDED
ELECTRODE VOLTAGES MEASURED TO GROUND





NOTES:

I. BOTTOM OF CUP MUST NOT BE USED AS A SOCKET STOP.

(A) MAX. ECCENTRICITY 0.015 INCHES

(B) MAX. ECCENTRICITY 0.008 INCHES

(C) MAX. ECCENTRICITY 0.018 INCHES

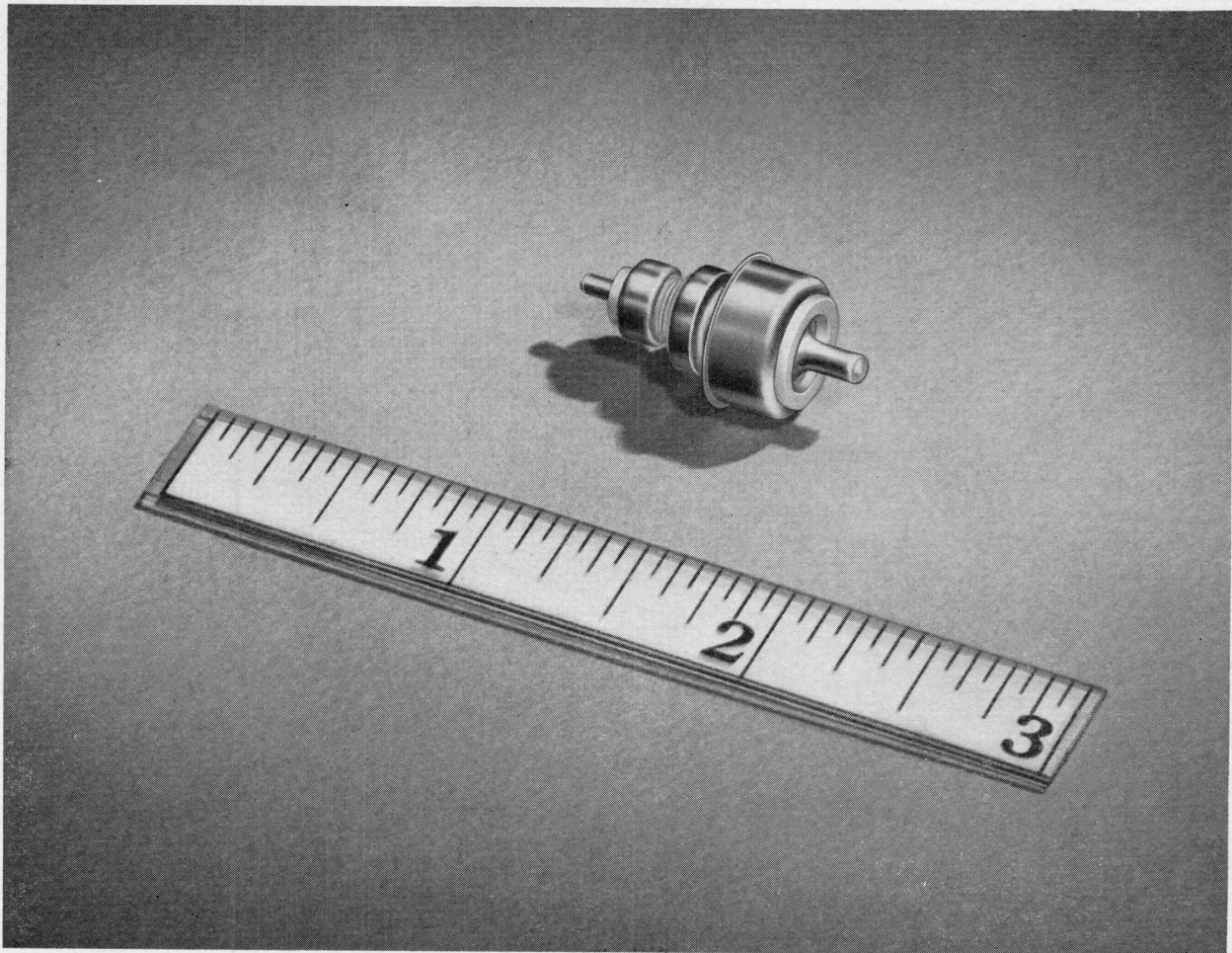
(D) MAX. ECCENTRICITY 0.021 INCHES

WITH RESPECT TO CENTERLINE DETERMINED BY CENTERS OF ANODE & CONTROL GRID TERMINALS.

ELECTRONIC COMPONENTS DIVISION

GENERAL  ELECTRIC

Schenectady 5, N. Y.



TRIODE

**LOW NOISE
UHF-SHF TRIODE
GROUNDED-GRID CIRCUIT**

**METAL AND CERAMIC
CONDUCTION COOLED
VERY SMALL SIZE**

The GL-6299 is designed for use in the radio-frequency stages of receivers operating at frequencies as high as 3000 megacycles. A receiver noise figure of less than 8.5 decibels at 1200 megacycles when the tube is used in a grounded-grid coaxial type circuit is an especially significant advantage of this type. Another advantage is the small size, only one inch long by one-half inch diameter, which makes the tube particularly well adapted to applications where space and weight are at a premium.

The planar electrode construction with very close

spacings reduces transit-time effects. The rigidity inherent in the tube design reduces microphonics and enables the tube to withstand shock and vibration. The envelope construction results in low losses, provides convenient electrode contact surfaces, and enables the tube to fit easily into coaxial circuits.

The cathode is the indirectly heated oxide-coated type with one end of the heater connected internally to the cathode. Cooling is accomplished by thermal contacts to the electrode terminals.

GENERAL  ELECTRIC

Supersedes ET-T1166A dated 6-56

TECHNICAL INFORMATION

GENERAL

Electrical	Minimum	Bogey	Maximum
Heater Voltage.....	6.0	6.3	6.6 Volts
Heater Current at 6.3 volts.....	280	300	320 Milliamperes
Direct Interelectrode Capacitances, approximate			
Grid to Anode.....	1.4	1.7	2.0 $\mu\mu\text{f}$
Grid to Cathode.....	2.5	3.5	5.0 $\mu\mu\text{f}$
Cathode to Anode.....		0.015	0.025 $\mu\mu\text{f}$
Characteristics, $E_b = 175$ v d-c, $I_b = 10$ ma d-c, E_g adjusted			
⊕ Transconductance.....	11,500	15,000	 Micromhos
Amplification Factor.....	85	115	140
Plate Resistance.....		9600	 Ohms
□ Anode Voltage, $I_b = 10$ ma, $E_c = 0$	75	125	175 Volts
Mechanical			
Mounting Position—Any			
Net Weight, approximate.....		$\frac{1}{6}$	Ounces
Thermal			
Cooling—Conduction*			
Envelope Temperature, maximum.....		150	C

* Good thermal contact to the anode and cathode must be provided to conduct heat from these elements. The anode contact must be sufficiently flexible to keep lateral force on the anode terminal at a minimum.

MAXIMUM RATINGS AND TYPICAL OPERATION

Maximum Ratings, Absolute Values

DC Plate Voltage.....	200	Volts
DC Plate Current.....	12	Milliamperes
Plate Dissipation.....	2	Watts
Positive Grid Voltage.....	0	Volts
Negative Grid Voltage.....	-15	Volts
Grid Current, except for initial-emission-velocity current†.....	0	Milliamperes

† Not rated for oscillator service.

Typical Operation—Class A₁ Amplifier

Grounded-Grid Coaxial-Type Circuit

Frequency.....	1200	1200	1200	3000	Megacycles
Bandwidth.....	10	10	10	10	Megacycles
Gain.....	17	17	17	11	Decibels
Noise Figure.....	8.2	8.2	8.5	13.2	Decibels
Anode Voltage.....	§	φ	175	φ	Volts
Grid Voltage†.....	0	0	¶	0	Volts
Filament Voltage.....	6.3	6.3	6.3	6.3	Volts
Anode Current.....	10	10	10	10	Milliamperes

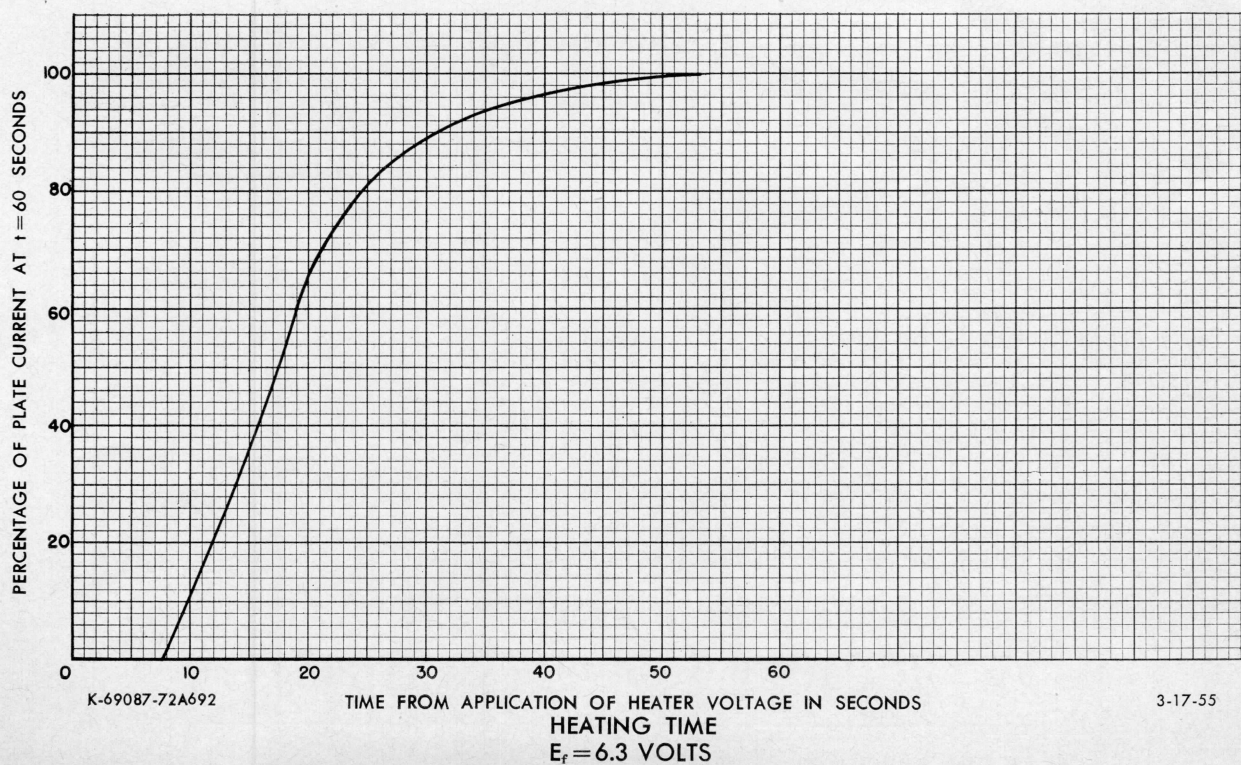
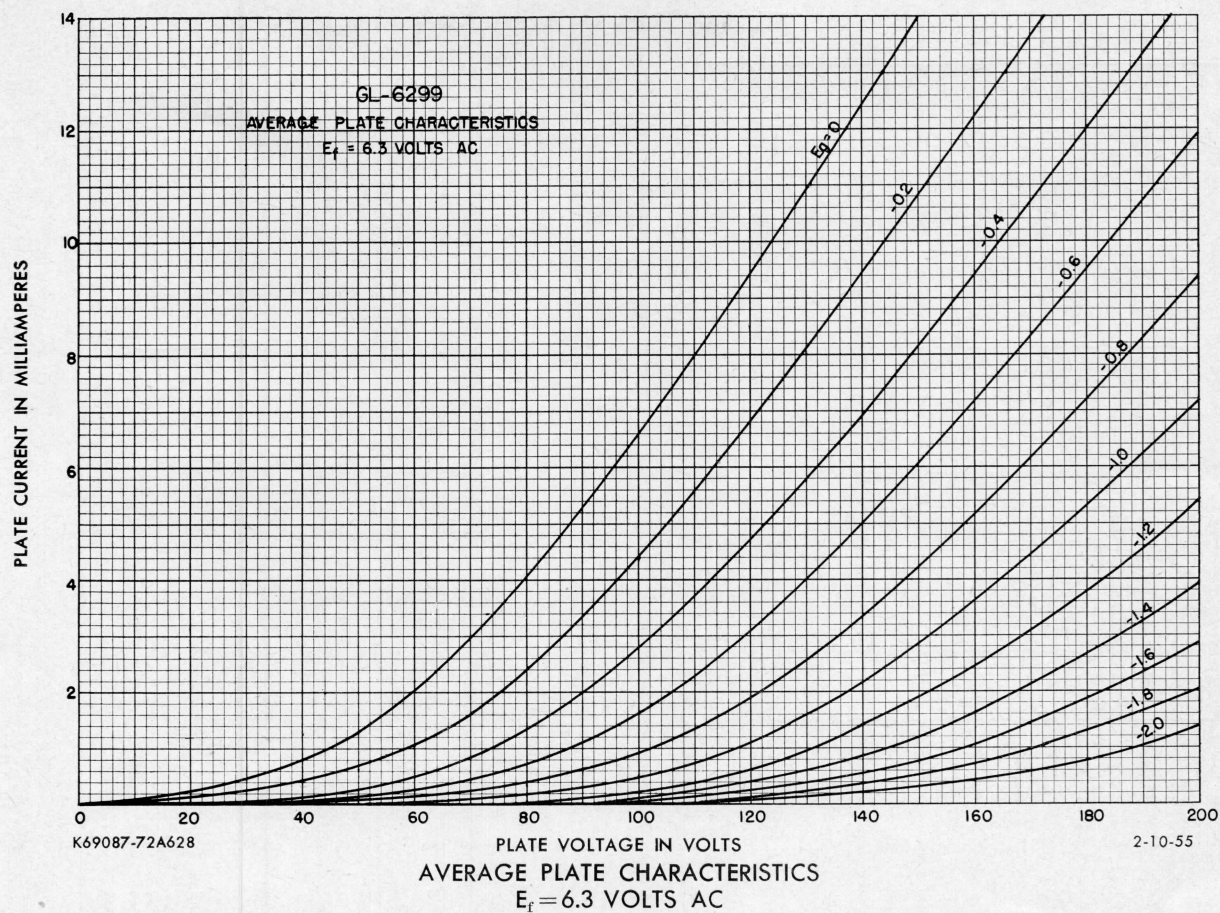
⊕ Denotes a change.

† For operation above 1000 megacycles the minimum noise figure will generally be obtained by operation at zero bias. For operation below 1000 megacycles the use of a cathode resistor or grid bias should be evaluated for the particular application.

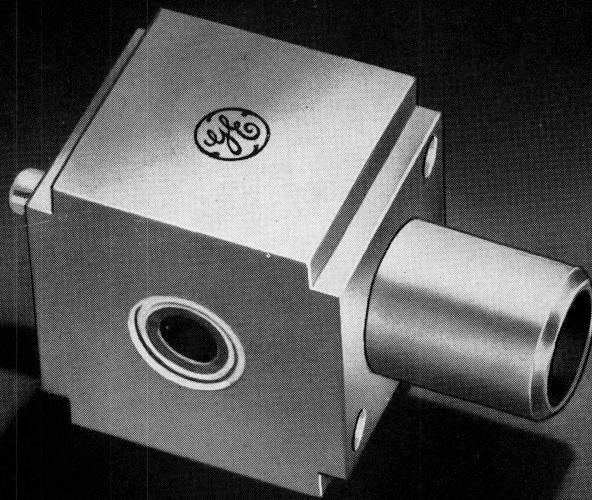
§ Recommended operation with regulated 300-volt plate-supply voltage through 17,500-ohm series anode resistor.

φ Adjust to give 10 milliamperes anode current (range must be variable from 75 to 200 volts).

¶ Adjust to give listed anode current: 200-ohm variable cathode resistor recommended.







REFERENCE CAVITY

**5 KILOWATTS
PRESSURIZED**

9270 MEGACYCLES

**TRANSMISSION TYPE
FIXED FREQUENCY**

The GL-6301 is a fixed-frequency, transmission-type vacuum-sealed resonant cavity for use at 9270 megacycles as a frequency-determining reference.

Particular advantages of this cavity are its

ability to operate from room temperature to -40°C with a maximum drift in resonant frequency of only plus or minus 0.4 megacycle and the fact that it can be used in a pressurized system.

TECHNICAL INFORMATION

GENERAL

Electrical

	Minimum	Bogey	Maximum
Resonant Frequency.....	9269.7	9270.0	9270.3 Megacycles
Source and Load Voltage Standing Wave Ratio at Resonant Frequency.....			1.05
Loaded Q.....	1000	1250	1500
Insertion Loss at Resonant Frequency.....	5	6.5	8 Decibels

Mechanical

Ambient Temperature Range.....	-65 to $+100^{\circ}\text{C}$
Mounting Position—Any	
Net Weight, approximate.....	8 Ounces


Electronic
TUBE

GENERAL  ELECTRIC

TECHNICAL INFORMATION (CONT'D)

MAXIMUM RATINGS

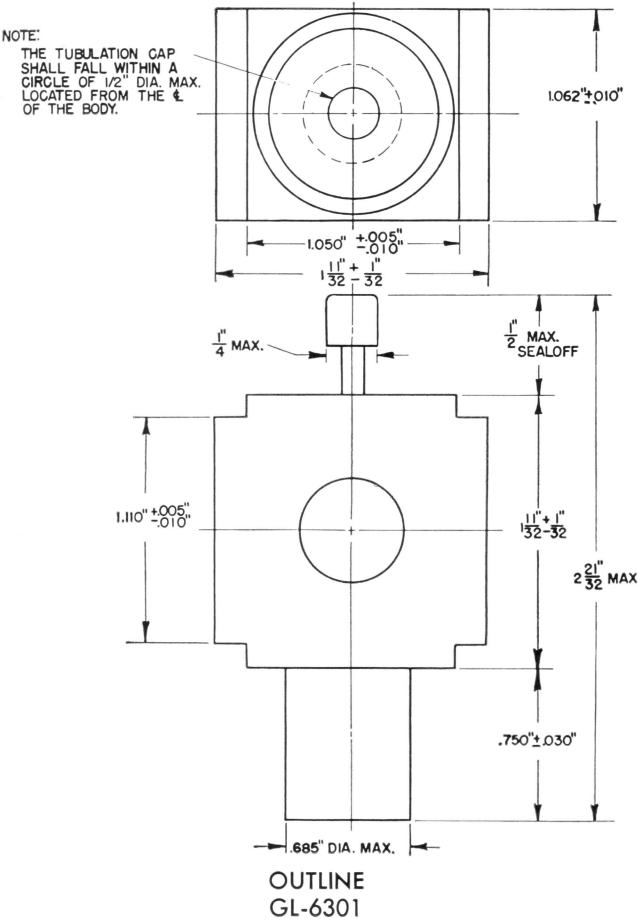
Incident Peak Power.....5 Kilowatts

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Resonant-Frequency Shift from Value at 25 C

With Ambient Temperature
Room Temperature to 80 C.....±0.3 Max Megacycles
Room Temperature to -40 C.....±0.4 Max Megacycles
Room Temperature to -55 C.....±0.5 Max Megacycles
With Vibration, 10 g's, 0.040" Displacement.....±0.1 Max Megacycles

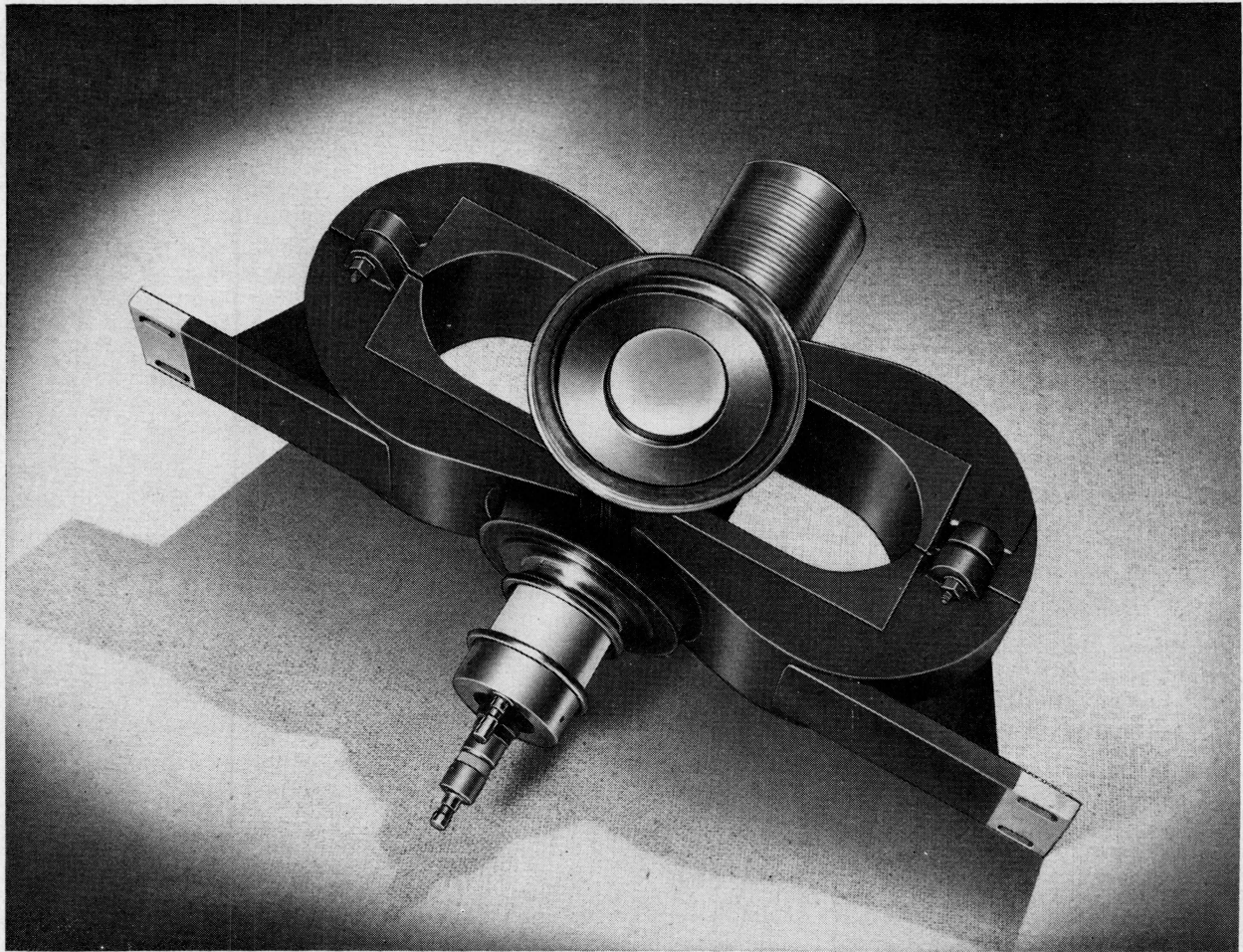
With Ambient Pressure
15 to 45 Pounds per Square Inch Absolute.....±0.15 Max Megacycles
15 Pounds per Square Inch Absolute to 100 Millimeters of Mercury Absolute.....±0.15 Max Megacycles



N-24560AZ

5-4-54

TUBE DEPARTMENT
GENERAL  ELECTRIC
Schenectady 5, N. Y.



MAGNETRON

2750-2860 MEGACYCLES
4.5 MEGAWATTS PEAK OUTPUT

INTEGRAL MAGNET
WATER COOLED

PULSED

The GL-6410 magnetron is a fixed-frequency pulsed-type oscillator tube.

TECHNICAL INFORMATION

GENERAL

Electrical

Cathode—Coated Unipotential	
Heater Voltage—Pre-Heat	8.3 ± 1 Volts
Heater Current at 8.3 Volts—Pre-Heat	85 Amperes
Heating Time—Pre-Heat, minimum	3 Minutes
Capacitance	
Measured between Anode and Cathode	27 μf

Mechanical

Mounting Position—Axis of Cathode in a Vertical Position	
Type of Cooling—Water	
Water Flow	2 Gallons per Minute
Pressure Drop, maximum	55 Pounds per Square Inch Absolute
Anode Temperature, maximum (See Outline on page 3 for details)	100 C
Cathode Stem Temperature, maximum (See Outline on page 3 for details)	200 C
Output Coupling—See Outline	
Load Transmission Line—RG-48/U Waveguide	
Net Weight, approximate	58 Pounds

GENERAL ELECTRIC

Supersedes pages 1 and 2 only dated 6-56

TECHNICAL INFORMATION (CONT'D)

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Maximum Ratings, Absolute Values

Duty Cycle	0.001	
Heater Voltage	9.3 Max	Volts
Heater Current	88 Max	Amperes
Heater Surge Current	100 Max	Amperes
Peak Anode Voltage	76 Max	Kilovolts
Peak Anode Current	135 Max	Amperes
Average Power Input	7 Max	Kilowatts
Pulse Duration*	2.2 Max	Microseconds
Output Circuit Pressurization	55 Max	Pounds per Square Inch Absolute
Voltage Standing Wave Ratio	1.5/1	

Typical Operation

Duty Cycle	0.00072	
Heater Voltage	8.3 $\pm$ 12%	Volts
Peak Anode Voltage	71	Kilovolts
Peak Anode Current	130	Amperes
Current Pulse Width	2	Microseconds
Voltage Pulse Time-of-Rise	0.3	Microseconds
Pulling Factor, VSWR 1.5/1, maximum	15	Megacycles
Pushing Factor, maximum	0.025	Megacycles per Ampere
Peak Power Output	4500	Kilowatts

* With the 6410 used as a load on the pulser, the pulser should deliver a pulse with the following characteristic:

Time of Rise of Current Pulse	0.25 Microseconds	Measured between 20 and 85 Percent of the Average Peak Current.
Time of Fall of Current Pulse	0.6 Microseconds	Measured between 0 and 85 Percent of the Average Peak Current.
Time of Rise of Voltage Pulse	0.5 Microseconds	Measured between 20 and 85 Percent of the Average Peak Voltage.
Time of Fall of Voltage Pulse	2.5 Microseconds	Measured between 0 and 85 Percent of the Average Peak Voltage.

The spike or ripple must not exceed $\pm$ 7 percent of the average peak value of the voltage or current, the inverse voltage must not exceed 20 percent of the forward voltage, and the negative amplitude of a post-voltage pulse oscillation must not exceed 10 percent of the average peak value.

X-RAY WARNING NOTICE

If the GL-6410 is operated at anode voltages in excess of 16 kilovolts, x-ray radiation shielding may be necessary to protect the user against possible danger of personal injury from prolonged exposure at close range. For further information consult the following references or other standard texts on the subject:

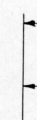
- (a) *X-Ray Protection Design*, Handbook No. 50. National Bureau of Standards, Washington, D. C.
- (b) *X-Ray Protection*, Handbook No. 60. National Bureau of Standards, Washington, D. C.

The above references are available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

During operation of the tube the high-voltage bushing must be immersed in a liquid insulating medium. General Electric 10 C insulating oil is recommended as having the proper insulating characteristics.

The tube should be mounted by means of the magnet brackets and in such a manner that these brackets support its entire weight. The equipment flanges mating to the cathode and output flanges must not be used for this purpose. Bellows or some other flexible union are recommended in connecting the cathode flange to the equipment flange.

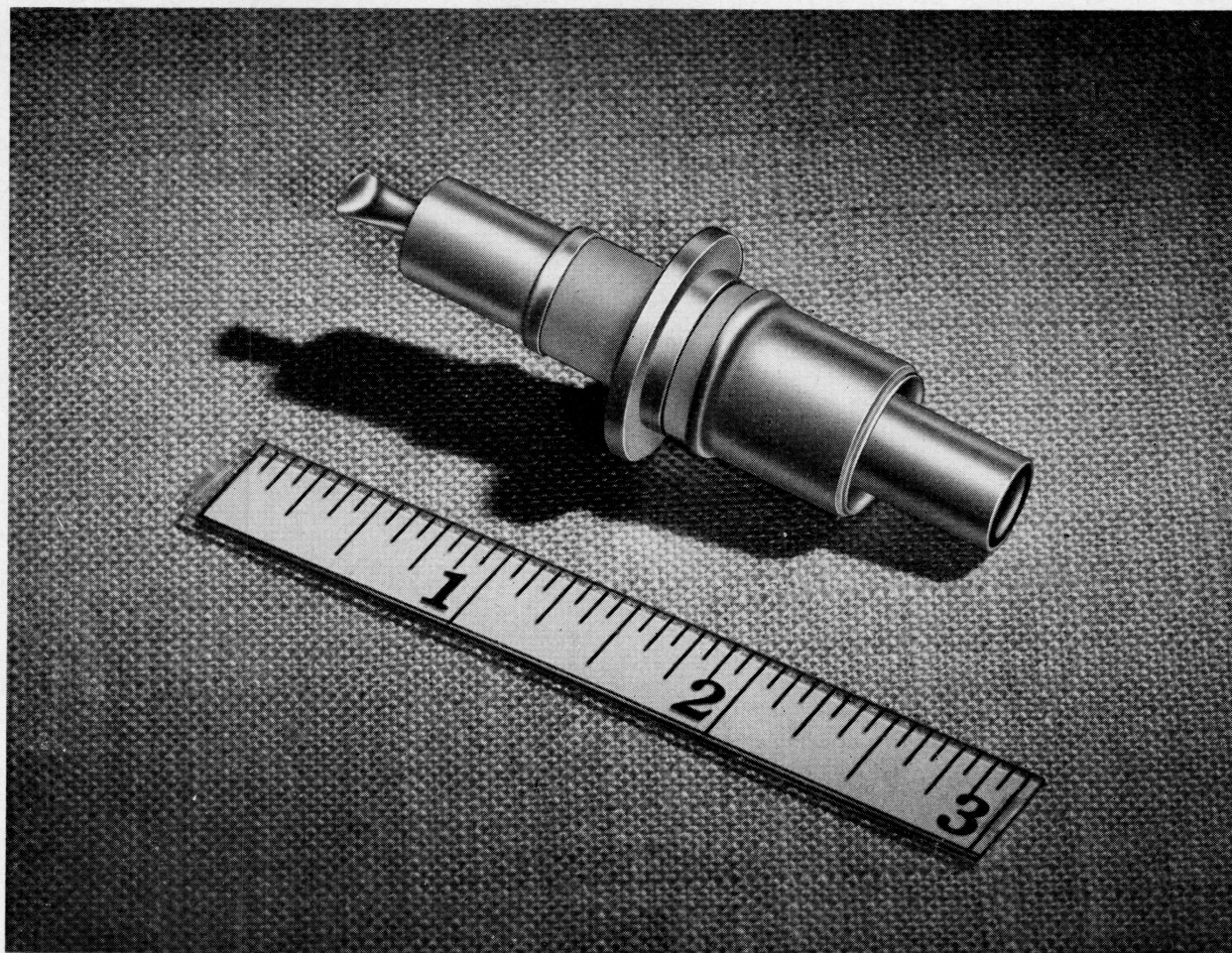
Clearance of 8 inches minimum must be maintained between the magnets and any ferro-magnetic materials in the equipment except at the bracket ends of the tube where 3 inches minimum clearance is satisfactory. A clearance of 12 inches minimum must be maintained between the permanent magnet of the tube and any other permanent magnet or electro-magnet.



9-8-54

7. Parts of this centerline may vary from true location by $\frac{3}{16}$ in.

TUBE DEPARTMENT
GENERAL ELECTRIC
Schenectady 5, N. Y.



TRIODE

**TWO KILOWATTS USEFUL POWER OUTPUT
UHF MEDIUM-MU TRIODE
GROUNDED-GRID SERVICE**

**LIGHTHOUSE TYPE
METAL AND CERAMIC
HIGH ELECTRICAL EFFICIENCY**

The GL-6442 is a medium-mu triode of lighthouse construction designed particularly for use in grounded-grid cavity circuits as a plate-pulsed oscillator at frequencies up to approximately 5000 megacycles per second. The tube is also useful as a radio-frequency power amplifier, continuous-wave oscillator, or frequency multiplier at frequencies up to approximately 2500 megacycles per second.

The tube features short electron transit time, low-interelectrode capacitances, low electrode lead inductance, and excellent isolation of the anode from the cathode for efficient operation at the higher frequencies. The metal and low-loss ceramic construction allows a design of extremely small

size—only $2\frac{1}{2}$ inches long and $\frac{19}{32}$ inches in diameter exclusive of the grid flange—and one that is sturdy, and light weight—important features in commercial and military equipment. Particular attention has been taken to obtain resistance to vibration and shock, and thermal stability in the parallel-plane electrode structure. Considerable care has been given to the design of the tube envelope and electrode terminals for efficient utilization of cavity resonators at the higher frequencies and of line-type and lumped-constant circuits at the lower frequencies. The heater is electrically separated from the cathode, which permits the use of a comparatively simple circuit.

GENERAL  ELECTRIC

▲Supersedes pages 1 thru 4 only dated 12-56

TECHNICAL INFORMATION

GENERAL

Electrical

Cathode—Indirectly Heated			
Heater Voltage*	6.3	+ 5% - 10%	Volts
Heater Current, AC or DC	0.9		Amperes
Cathode Heating Time for Pulsed Operation, minimum	1		Minutes
Direct Interelectrode Capacitances, approximate			

	Minimum	Bogey	Maximum	
Grid to Plate	2.10	2.3	2.45	μmf
Grid to Cathode, $E_h=0$	4.60	5.10	5.45	μmf
Plate to Cathode, $E_h=0$		0.035	0.045	μmf

Mechanical

Cooling—Conduction and Convection			
Mounting Position—Any			
Envelope Temperature	175	Max	C
Net Weight, approximate	1		Ounce

Characteristics

Class A ₁ Amplifier				
Plate Voltage			350	Volts
DC Grid Bias, approximate	-2.5	-4.25	-5.75	Volts
Amplification Factor, approximate, $E_c/I_b=35$ ma d-c	35	50	65	
Transconductance	13,500	16,500	19,000	Micromhos
Plate Current			35	Milliamperes

MAXIMUM RATINGS AND TYPICAL OPERATION

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEPHONY

Carrier Conditions per Tube for Use with a Maximum Modulation Factor of 1.0

Maximum Ratings, Absolute Values

Frequency	2500	Max	Megacycles
DC Plate Voltage	275	Max	Volts
DC Grid Voltage	-50	Max	Volts
DC Plate Current	35	Max	Milliamperes
DC Grid Current	15	Max	Milliamperes
Plate Input	9.5	Max	Watts
Plate Dissipation	6.0	Max	Watts
Peak Heater-Cathode Voltage			
Heater Negative with Respect to Cathode	90	Max	Volts
Heater Positive with Respect to Cathode	90	Max	Volts

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

Key-Down Conditions per Tube without Amplitude Modulation†—CW Operation

Maximum Ratings, Absolute Values

Frequency	2500	Max	Megacycles
DC Plate Voltage	350	Max	Volts
DC Grid Voltage	-50	Max	Volts
DC Plate Current	35	Max	Milliamperes
DC Grid Current	15	Max	Milliamperes
Plate Power Input	12	Max	Watts
Plate Dissipation	8	Max	Watts
Peak Heater-Cathode Voltage			
Heater Negative with Respect to Cathode	90	Max	Volts
Heater Positive with Respect to Cathode	90	Max	Volts

TECHNICAL INFORMATION (CONT'D)

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

Plate-Pulsed Operation

Maximum Ratings, Absolute Values

For a Maximum Conducting Period of 5 Microseconds in any 5000-Microsecond Interval.

Frequency.....	5000	Max	Megacycles
Duty Factor†.....	0.001		
Peak Positive-Pulse Plate-Supply Voltage.....	3000	Max	Volts
Peak Negative-Pulse Grid-Bias Voltage.....	100	Max	Volts
Peak Plate Current from Pulse Supply§.....	2.5	Max	Amperes
Peak Rectified Grid Current.....	1.25	Max	Amperes
DC Plate Current.....	2.5	Max	Milliamperes
DC Grid Current.....	1.25	Max	Milliamperes
Plate Input.....	7.5	Max	Watts
Plate Dissipation.....	7.5	Max	Watts
Pulse Duration.....	2.0	Max	Microseconds
Cathode Heating Time.....	1	Min	Minute
Peak Heater-Cathode Voltage			
Heater Negative with Respect to Cathode.....	90	Max	Volts
Heater Positive with Respect to Cathode.....	90	Max	Volts

Typical Operation

Self-Excited Oscillator with Rectangular Wave Shape

Frequency.....	3500	5000	Megacycles
Heater Voltage.....	6.0	6.0	Volts
Duty Factor.....	0.001	0.001	
Peak Positive-Pulse Plate-Supply Voltage.....	3000	3000	Volts
Peak Negative-Pulse Grid-Bias Voltage, approximate.....	75	75	Volts
Grid-Bias Resistor, approximate.....	50	50	Ohms
Peak Current from Pulse Supply.....	2.5	2.5	Amperes
Peak Rectified Grid Current.....	1.25	1.25	Amperes
DC Plate Current.....	2.5	2.5	Milliamperes
DC Grid Current.....	1.25	1.25	Milliamperes
Useful Power Output at Peak of Pulse, approximate.....	2.0	0.5	Kilowatts
Pulse Duration.....	1.0	1.0	Microseconds
Pulse Repetition Rate.....	1000	1000	Pulses per Second

Grid-Pulsed Operation

Maximum Ratings, Absolute Values

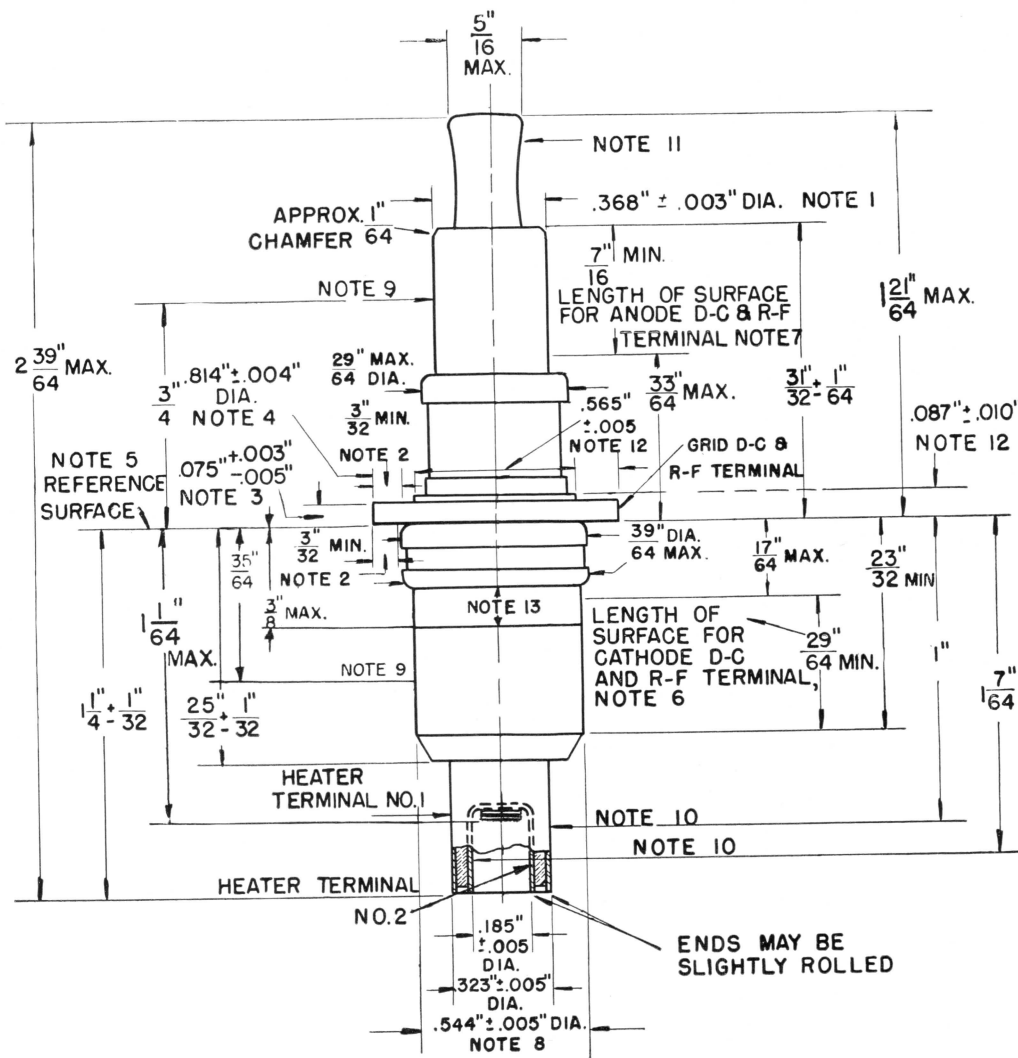
Frequency.....	2500	Max	Megacycles
DC Plate Voltage.....	350	Max	Volts
DC Grid Voltage.....	-50	Max	Volts
DC Plate Current.....	35	Max	Milliamperes
DC Grid Current.....	15	Max	Milliamperes
Plate Power Input.....	12	Max	Watts
Plate Dissipation.....	8	Max	Watts
Peak Heater-Cathode Voltage			
Heater Negative with Respect to Cathode.....	90	Max	Volts
Heater Positive with Respect to Cathode.....	90	Max	Volts

* The GL-6442 operates at frequencies where transit-time effects of the electron current must be considered. The principal effects influencing the operation are the decrease in power output and operating efficiency with increase in frequency, and the bombardment and heating of the cathode by electrons from the region of the grid, which can be sufficiently severe to result in short tube life and erratic operation. Operating frequency, circuit design and adjustment, grid bias, grid current, average power, input, and the operating voltage contribute in some degree to the magnitude of the resulting cathode bombardment. There is a heater voltage which will maintain the cathode at the correct operating temperature for a particular set of operating conditions. If the conditions of operation result in appreciable cathode back-heating, it will be necessary to initiate dynamic operation of the tube at normal heater voltage, followed by a reduction of heater voltage to the proper value. A maximum variation of plus or minus five percent in heater voltage is recommended where consistent operation and extended tube life is a factor. For application above 500 megacycles, recommendations are to be obtained from the tube manufacturer regarding the heater voltage to be used under a specific set of operating conditions.

† Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 percent of the carrier conditions.

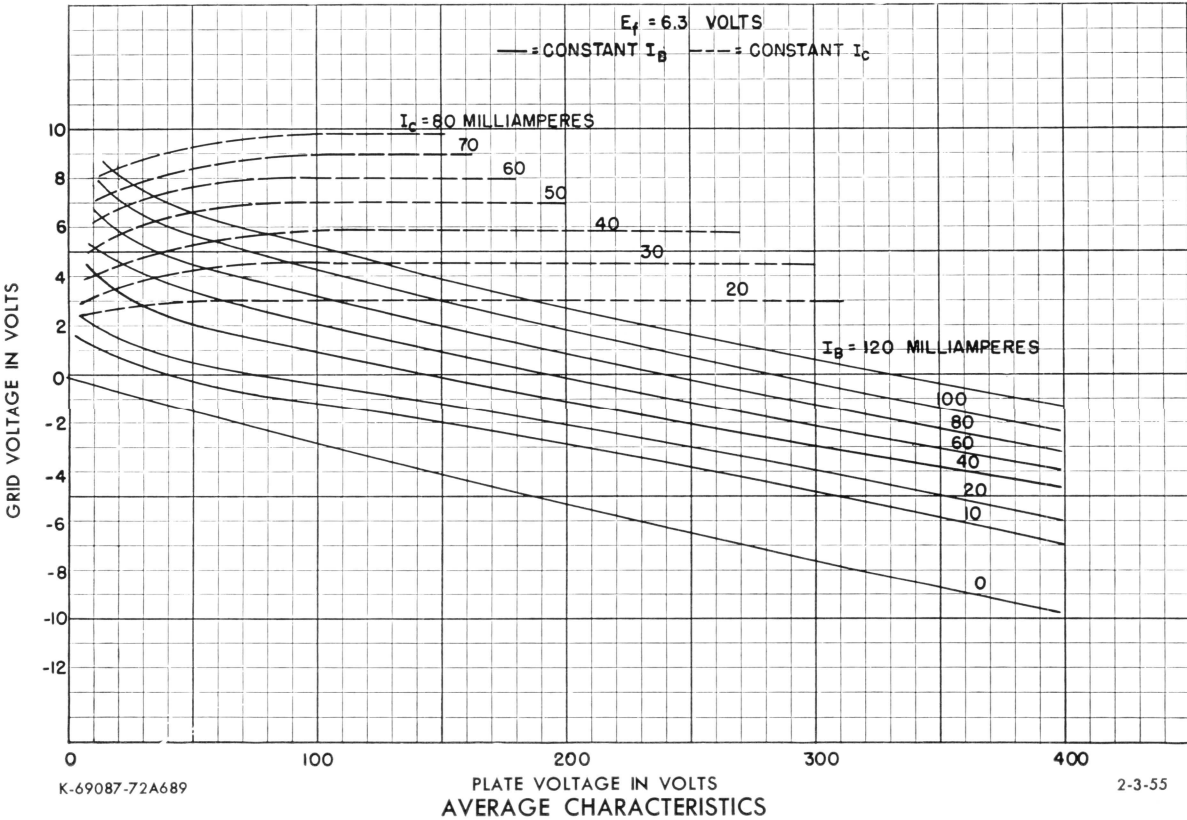
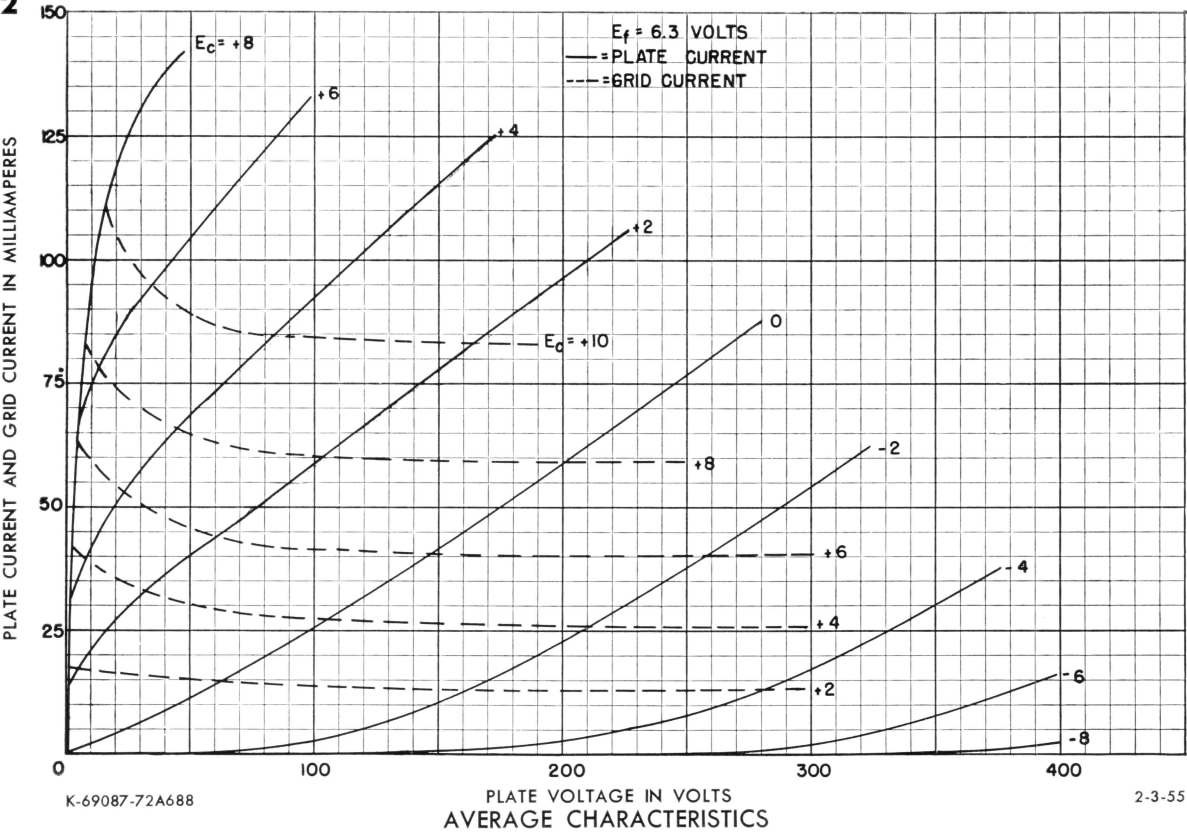
‡ For applications above a duty factor of 0.001 refer to the tube manufacturer for recommendations.

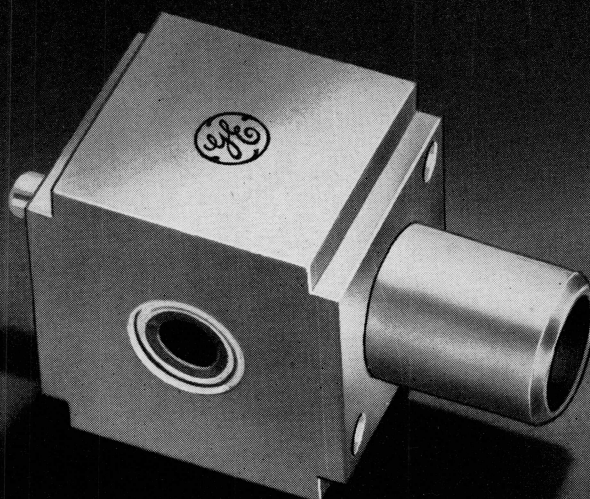
§ The regulation and/or series-plate supply impedance shall be such as to limit the instantaneous peak current, with the tube considered as a short circuit, to a maximum of 10 times the specified maximum current rating.



REFERENCE NOTES FOR OUTLINE DRAWING

- Note 1. Applies to minimum surface for anode d-c and r-f terminal only. Other surfaces must not be used for these terminal purposes.
- Note 2. Applies to minimum surface for grid d-c and r-f terminal only. Other surfaces, except for Notes 3 and 4, must not be used for terminal purposes.
- Note 3. Applies to minimum surfaces for grid d-c and r-f terminal only.
- Note 4. The cylindrical surface of this diameter may be used for grid d-c and r-f terminal purposes.
- Note 5. The surfaces defined by Notes 2, 3 and 4 must be the only surfaces used for tube stops and clamping purposes.
- Note 6. Other surfaces must not be used for cathode d-c and r-f terminal purposes.
- Note 7. Other surfaces must not be used for anode d-c and r-f terminal purposes.
- Note 8. Applies to surface designated for cathode d-c and r-f terminal. Solder at brazed joint will not exceed the maximum diameter.
- Note 9. The maximum eccentricity of the anode and cathode with respect to the grid terminal in a prescribed jig is 0.010 (or maximum total runout of 0.020) and is measured by indicators at the points designated.
- Note 10. The maximum eccentricity of heater-terminal No. 1 and heater-terminal No. 2 with respect to the grid terminal in a prescribed jig is 0.015 (or maximum total runout of 0.030) and is measured by indicators at the points designated.
- Note 11. Exhaust tubulation must not be subjected to any mechanical stress.
- Note 12. For reference only. Dimension does not include any possible solder fillet.
- Note 13. This area is reserved for tube stamping and coding.





REFERENCE CAVITY

**5 KILOWATTS
PRESSURIZED**

9350 MEGACYCLES

**TRANSMISSION TYPE
FIXED FREQUENCY**

The GL-6452 is a fixed-frequency, transmission-type, vacuum-sealed resonant cavity for use as a frequency-determining reference at 9350 megacycles.

ability to operate from room temperature to -40°C with a maximum drift in resonant frequency of only plus or minus 0.4 megacycle and the fact that it can be used in a pressurized system.

Particular advantages of this cavity are its

TECHNICAL INFORMATION

GENERAL

Electrical

	Minimum	Bogey	Maximum
Resonant Frequency.....	9349.7	9350.0	9350.3 Megacycles
Source and Load Voltage Standing Wave Ratio at Resonant Frequency.....			1.05
Loaded Q.....	1500	1750	2000
Insertion Loss at Resonant Frequency.....	...	4	6 Decibels

Mechanical

Ambient Temperature Range.....	-65 to $+100^{\circ}\text{C}$
Mounting Position—Any	
Net Weight, approximate.....	8 Ounces

TECHNICAL INFORMATION (CONT'D)

MAXIMUM RATINGS

Incident Peak Power 5 Kilowatts

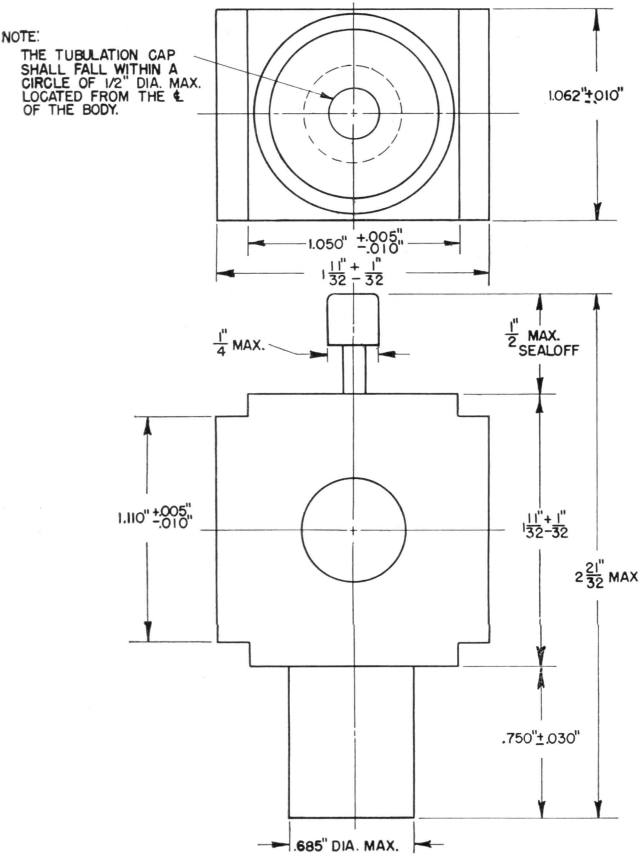
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

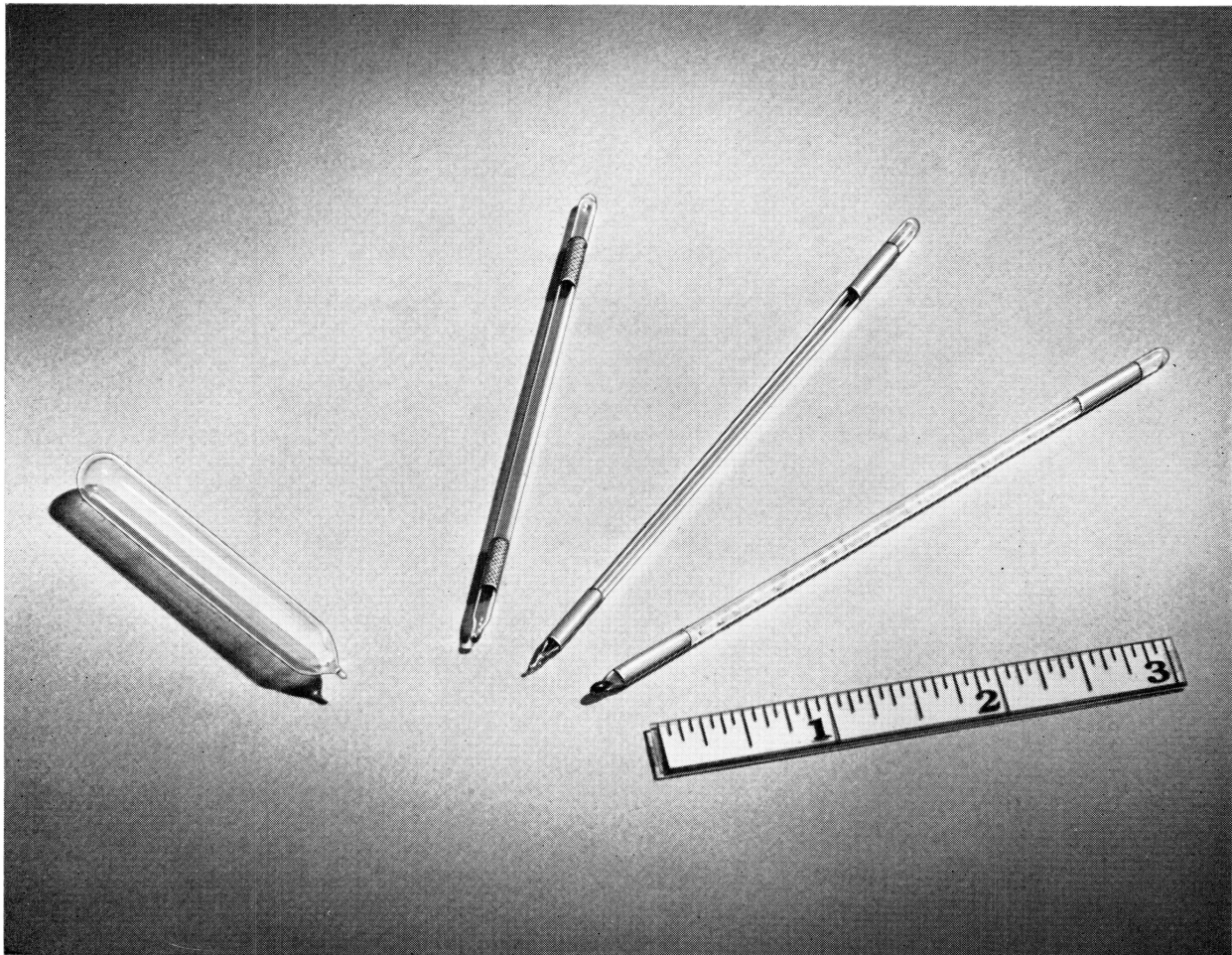
Resonant-Frequency Shift from Value at 25 C

With Ambient Temperature
Room Temperature to 80 C ± 0.4 Max Megacycles
Room Temperature to -40 C ± 0.4 Max Megacycles
Room Temperature to -55 C ± 0.5 Max Megacycles

With Vibration, 10 g's, 0.040" Displacement ± 0.1 Max Megacycles

With Ambient Pressure
15 to 45 Pounds per Square Inch Absolute ± 0.15 Max Megacycles
15 Pounds per Square Inch Absolute to 100 Millimeters of Mercury Absolute ± 0.15 Max Megacycles





GAS-DISCHARGE DEVICE

These gas-discharge devices are for use in polarization or branching-type duplexers in radar systems. In such service they perform the same function as A-TR and Pre-TR tubes and can be used to replace these switching tubes where higher

power levels are required. In operation the gas-filled envelope ionizes to form a highly conductive gas column when high radio-frequency power is applied during the transmission period, and deionizes when the power is removed.

APPLICATION

GL-6619—Groups of ten to twenty in polarization twist duplexers, 2700 to 2900 megacycles.

GL-6620—Groups of two in branching-type duplexers, 3400 to 3600 megacycles.

GL-6621—Groups of ten to twenty in polarization twist duplexers, 2700 to 2900 megacycles.

GENERAL  ELECTRIC

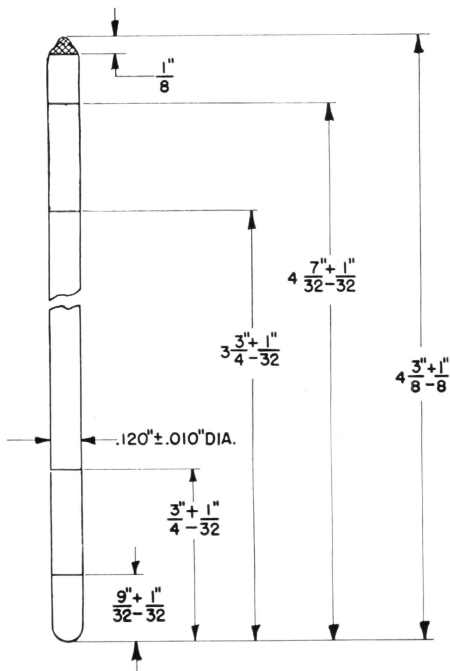
Supersedes ET-T1164 dated 2-55

TECHNICAL INFORMATION

GENERAL

Tube Type Number	GL-6619	GL-6620	GL-6621	
Electrical				
Firing Power	250	250	250	Min Kilowatts
	Tube axis 85 degrees from direction of electric field vector.			
Recovery Time (single tube)	25	40	50	Max Microseconds
	Peak power = 50 kw; pulse repetition rate = 1000 pps; pulse duration = 1.0 μ sec; magnetron frequency = 2800 ± 20 mc; probing signal fre- quency = 2900 ± 30 mc.	Peak power = 50 kw; pulse repetition rate = 1000 pps; pulse duration = 1.0 μ sec; magnetron frequency = 3500 ± 20 mc; probing signal fre- quency = 3570 ± 30 mc.	Peak power = 50 kw; pulse repetition rate = 1000 pps; pulse duration = 1.0 μ sec; magnetron frequency = 2800 ± 20 mc; probing signal fre- quency = 2900 ± 30 mc.	
	Tube axis is parallel to incident electric field vector.			
Mechanical				
Mounting Position	Any	Any	Any	
Ambient Temperature Range (non-operating)	-40 to +100	-40 to +100	-40 to +100	C
Net weight, approximate	3	3	2	Ounces
Maximum Ratings				
Transmitter Peak Power	2.5	1.5⊕	5	Megawatts
Frequency Range	2700 to 2900	3400 to 3600	2700 to 2900	Megacycles per Second

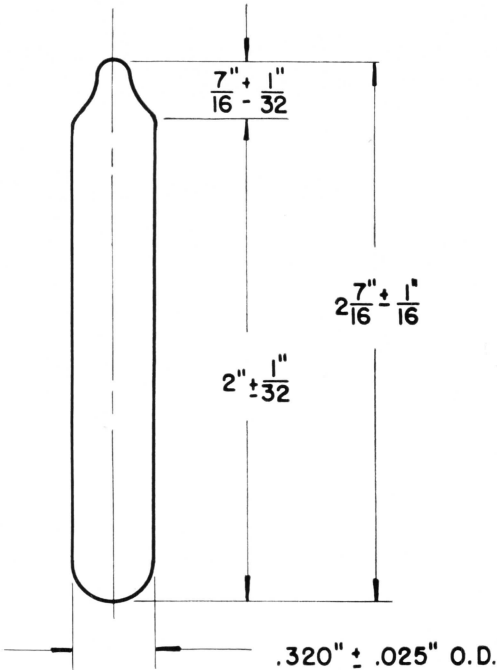
⊕ Denotes a change.



K-69087-186A67

1-24-55

OUTLINE
GL-6619, GL-6621



K-69087-186A78—Outline Revised

8-21-56

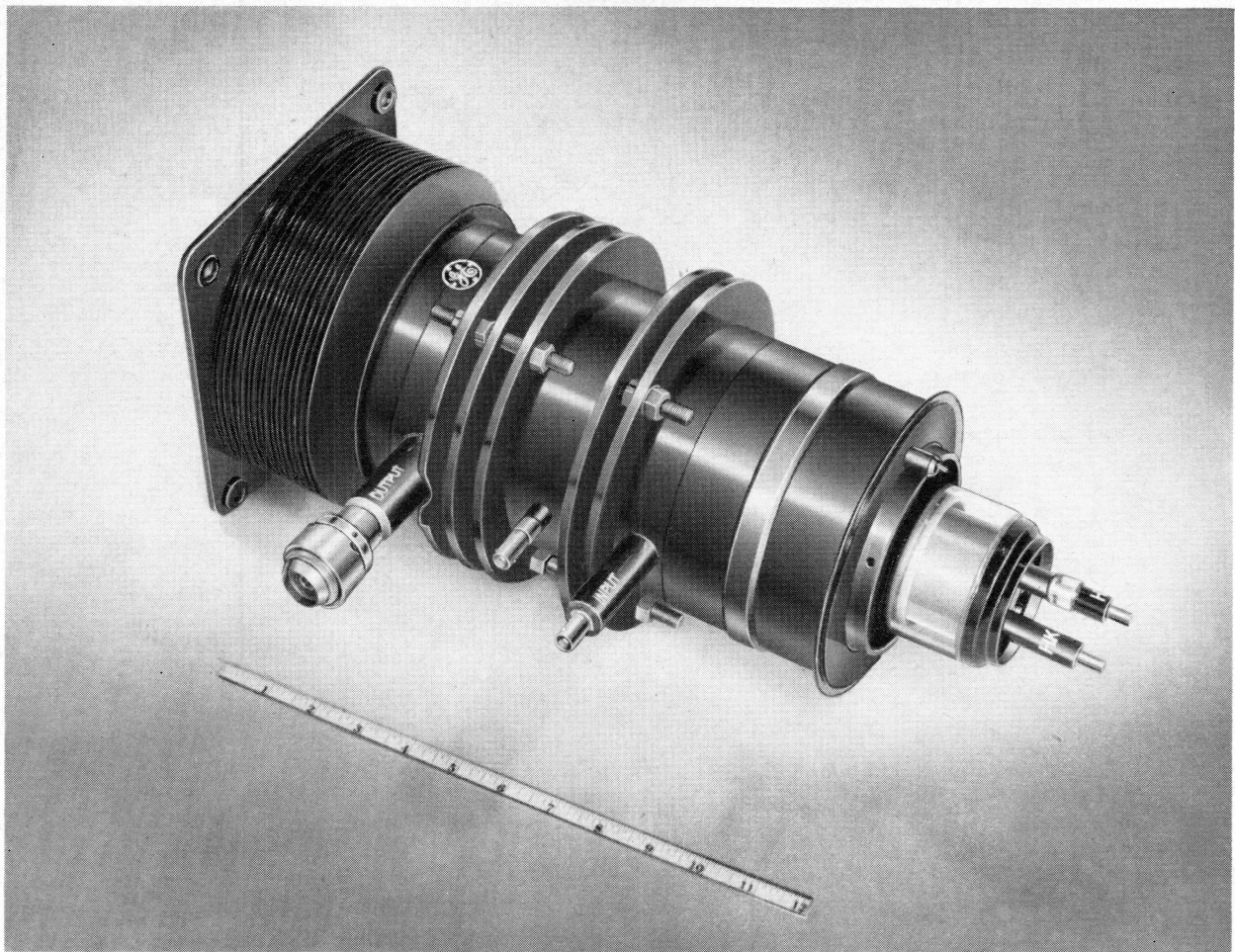
OUTLINE
GL-6620

ELECTRONIC COMPONENTS DIVISION

GENERAL  ELECTRIC

Schenectady 5, N. Y.

PRINTED
IN
U.S.A.



KLYSTRON

960-1215 MEGACYCLES

22 KILOWATTS PEAK OUTPUT

INTEGRAL RESONATORS

ELECTROSTATICALLY FOCUSED

The GL-6625 is a three-resonator tunable amplifier klystron for pulsed operation up to a maximum duty of twelve percent. The tube covers a frequency range of 960 to 1215 megacycles and will provide a peak power output of 22 kilowatts. The uni-potential cathode is oxide-coated and indirectly heated. The rf output coupling is for $\frac{7}{8}$ -inch

coaxial 50-ohm line and matches UG-1126/U connectors. The input and center-cavity-monitor fittings are BNC type to accommodate UG-88/U connectors. The tube is forced-air cooled, features mechanically tuned integral resonators, and is electrostatically focused, which eliminates the necessity for external magnets or focus coils.

GENERAL  ELECTRIC

TECHNICAL INFORMATION

GENERAL

Electrical

	Minimum	Bogey	Maximum
Heater Voltage.....	4.5	5.0	5.5 Volts
Heater Current at 5 Volts.....	35	....	45 Amperes
Heater Starting Current.....	....	....	70 Amperes
Heater Cold Resistance.....	....	0.02	 Ohms
Cathode Heating Time.....	5.0	....	.... Minutes
Frequency.....	960	....	1215 Megacycles
Capacitance, cathode gun.....	....	35	 $\mu\mu\text{f}$

Mechanical

Mounting Position—Any		
Net Weight, approximate.....	30	Pounds

Thermal

Air Flow.....	220 Min	Cubic Feet per Minute
Air flow of at least 220 cubic feet per minute is required for operation at maximum ratings. In any case, sufficient air cooling must be provided and distributed to keep temperatures below the indicated limits.		
Operating Temperature		
Tube Body.....	100 Max	C
Cooling Fin Assembly.....	125 Max	C

MAXIMUM RATINGS AND TYPICAL OPERATION

RADIO-FREQUENCY PULSE AMPLIFIER

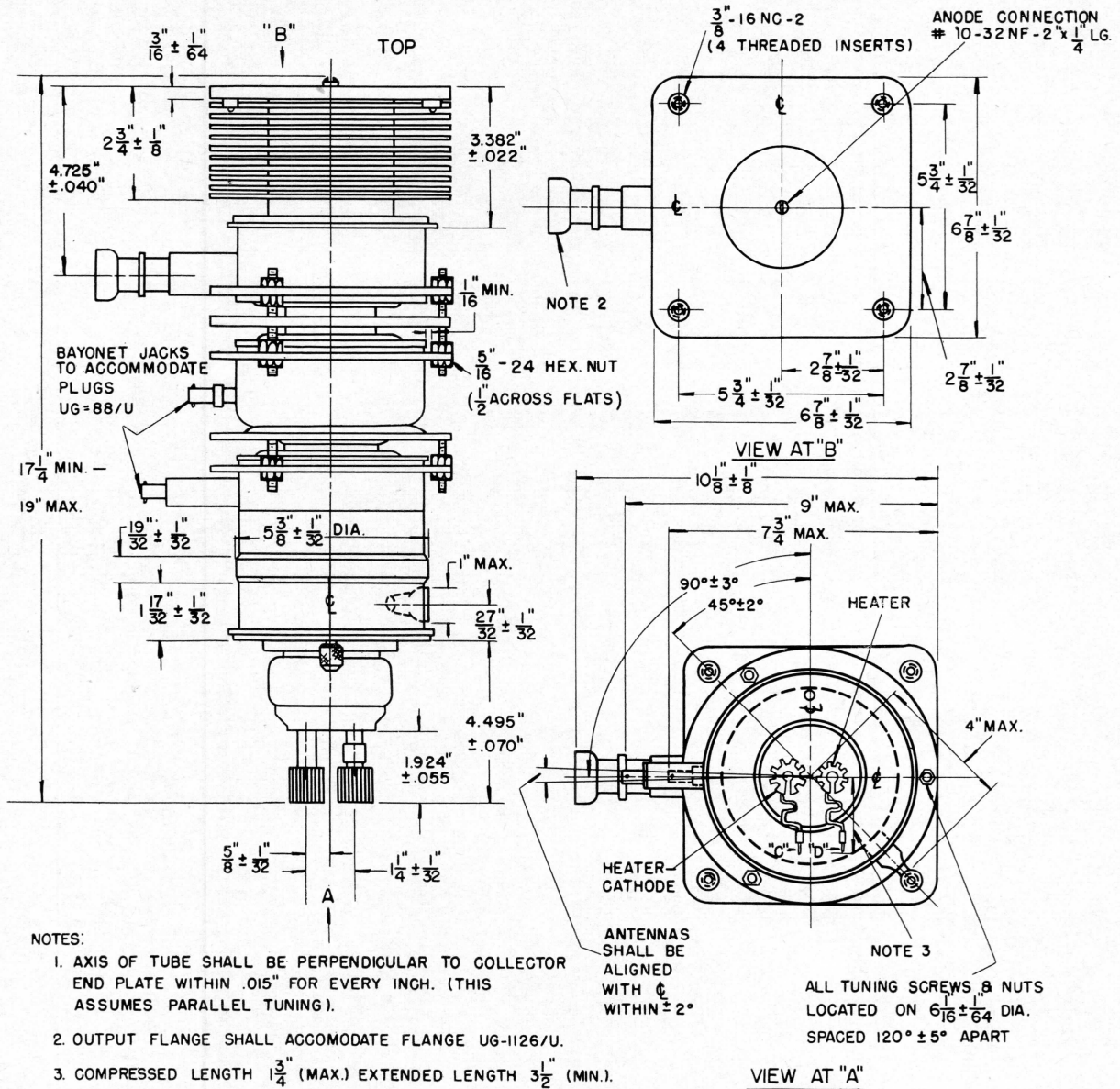
Maximum Ratings, Absolute Values

Peak Beam Voltage.....	20 Max	Kilovolts
Peak Beam Current.....	9.35 Max	Amperes
Average Beam Power.....	2400 Max	Watts
RF Output Power, average.....	300 Max	Watts
Beam Pulse Width.....	10 Max	Microseconds
Duty Cycle.....	12	Percent

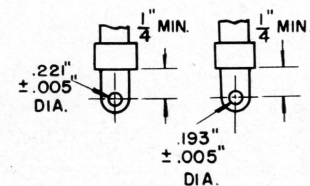
For periods of time not to exceed one millisecond, duty cycles up to forty percent may be used.

Typical Operation

Peak Beam Voltage.....	10	18	Kilovolts
Peak Beam Current.....	3	6.6	Amperes
Peak RF Input Power.....	40	100	Watts
Peak RF Output Power.....	7.5	22	Kilowatts
RF Pulse Width.....	3.5	3.5	Microseconds
Duty Cycle.....	6	1	Percent



VIEW AT "A"



VIEW AT "C" VIEW AT "D"

TUBE DEPARTMENT
GENERAL ELECTRIC
Schenectady 5, N. Y.



TRIODE

HIGH-MU TRIODE

PARALLEL-PLANE TYPE UP TO 4000 MEGACYCLES

GROUND-GRID SERVICE METAL AND CERAMIC

The GL-6771 is a general-purpose, high-mu triode of metal-and-ceramic parallel-plane construction for use in grounded-grid service as a radio-frequency amplifier, oscillator, or frequency multiplier. As a continuous-wave oscillator, it will deliver approximately 300 milliwatts of non-squegging power at 4000 megacycles. As a frequency multiplier, doubling from 500 to 1000 megacycles, it will deliver approximately 2 watts of power output with only 300 milliwatts of driving power.

The improved lighthouse construction of the 6771 has several advantages over previous types; short electron transit time, low interelectrode capacitances, and very low electrode lead inductances. The heater and cathode are electrically separated.

The metal-and-low-loss-ceramic construction re-

sults in a design of extremely small size, only $2\frac{5}{8}$ inches long and $\frac{1}{32}$ inch in diameter exclusive of the grid flange. The tube is light in weight and features a very rugged structure that will withstand not only severe vibration but shock at 400 g's. The envelope and electrode terminals are designed to assure efficient utilization of line-type and lumped-constant circuits at the lower frequencies and of cavity resonators at the higher frequencies.

The characteristics and ratings of the GL-6771 combined with these design features recommend it for use in microwave applications requiring efficient tube operation under stringent environmental conditions. Such applications include communications, radar, telemeters and altimeters, and navigation and test equipment.

TECHNICAL INFORMATION

GENERAL

Electrical

Cathode—Indirectly Heated		
Heater Voltage	6.3	Volts
Heater Current	0.57	Amperes
Direct Interelectrode Capacitances, approximate		
Grid to Plate	2.0	μmf
Grid to Cathode, $E_f=0$	4.05	μmf
Plate to Cathode, $E_f=0$	0.018	μmf

Mechanical

Mounting Position—Any		
Net Weight, approximate	0.9	Ounces

Thermal

Type of Cooling—Conduction and Convection		
Envelope Temperature	175	Max C

Characteristics

Plate Voltage	250	Volts
Plate Current	25	Milliamperes
Grid Voltage, approximate	1.6	Volts
Amplification Factor	90	
Transconductance	23,000	Micromhos

MAXIMUM RATINGS AND TYPICAL OPERATION

CLASS A RADIO-FREQUENCY AMPLIFIER

Maximum Ratings, Absolute Values

Heater Voltage	5.7 $\pm 5\%$	Volts
DC Plate Voltage	300	Volts
DC Grid Voltage	-25	Volts
DC Plate Current	25	Milliamperes
Plate Dissipation	6.25	Watts
Peak Heater-Cathode Voltage		
Heater Negative	90	Volts
Heater Positive	90	Volts
Maximum Grid-Circuit Resistance	0.5	Megohms

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

Key-down Conditions without Amplitude Modulation

Maximum Ratings, Absolute Values

Heater Voltage*		
DC Plate Voltage	275	Volts
DC Plate Current	25	Milliamperes
DC Grid Voltage	-25	Volts
DC Grid Current	8	Milliamperes
Plate Power Input	7	Watts
Plate Dissipation	6.25	Watts
Peak Heater-Cathode Voltage		
Heater Negative	90	Volts
Heater Positive	90	Volts
Maximum Grid-Circuit Resistance	0.1	Megohms

Typical Operating Conditions

CW Radio-Frequency Oscillator, 4000 Megacycles		
Heater Voltage	5.0	Volts
DC Plate Voltage	250	Volts
DC Plate Current	25	Milliamperes
DC Grid Voltage	-1.7	Volts
DC Grid Current	0.6	Milliamperes
CW Power Output	300	Milliwatts

TECHNICAL INFORMATION (CONT'D)

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEPHONY

Carrier Conditions per Tube for Use with a Maximum Modulation Factor of 1.0

Maximum Ratings, Absolute Values

Heater Voltage*		
DC Plate Voltage	250	Volts
DC Plate Current	22	Milliamperes
DC Grid Voltage	-25	Volts
DC Grid Current	8	Milliamperes
Plate Input	5.5	Watts
Plate Dissipation	5.0	Watts
Peak Heater-Cathode Voltage		
Heater Negative	90	Volts
Heater Positive	90	Volts
Maximum Grid-Circuit Resistance	0.1	Megohms

RADIO-FREQUENCY MULTIPLIER

Maximum Ratings, Absolute Values

Heater Voltage*		
DC Plate Voltage	250	Volts
DC Plate Current	20	Milliamperes
DC Grid Voltage	-50	Volts
DC Grid Current	5	Milliamperes
Plate Input	5.0	Watts
Plate Dissipation	5.0	Watts
Peak Heater-Cathode Voltage		
Heater Negative	90	Volts
Heater Positive	90	Volts
Maximum Grid-Circuit Resistance	0.1	Megohms

Typical Operating Conditions

Radio-Frequency Doubler—500–1000 Megacycles

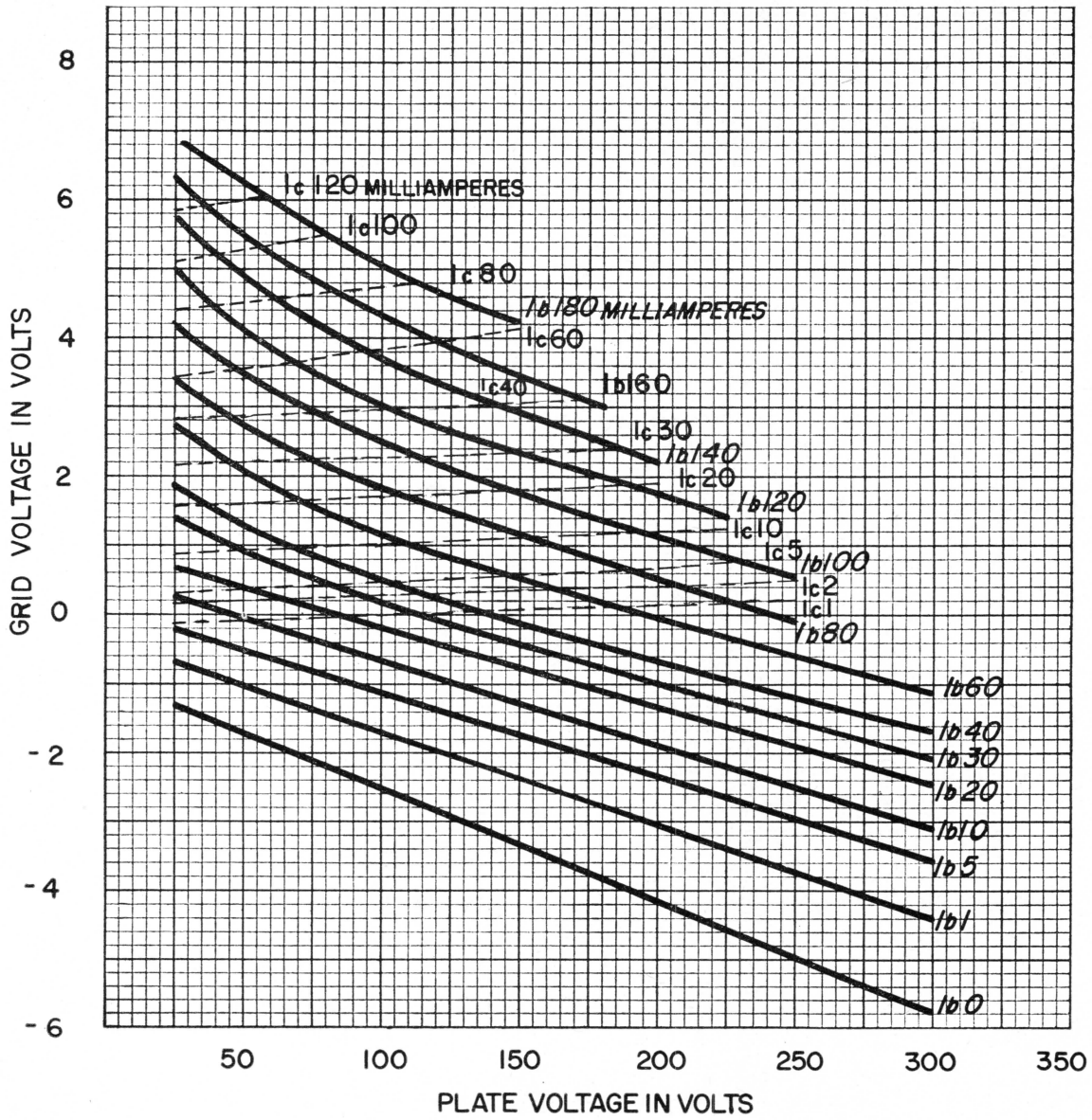
Heater Voltage	5.7	Volts
DC Plate Voltage	250	Volts
DC Plate Current	20	Milliamperes
DC Grid Voltage	10	Volts
DC Grid Current	5	Milliamperes
RF Power Input	300	Milliwatts
RF Power Output	2.0	Watts

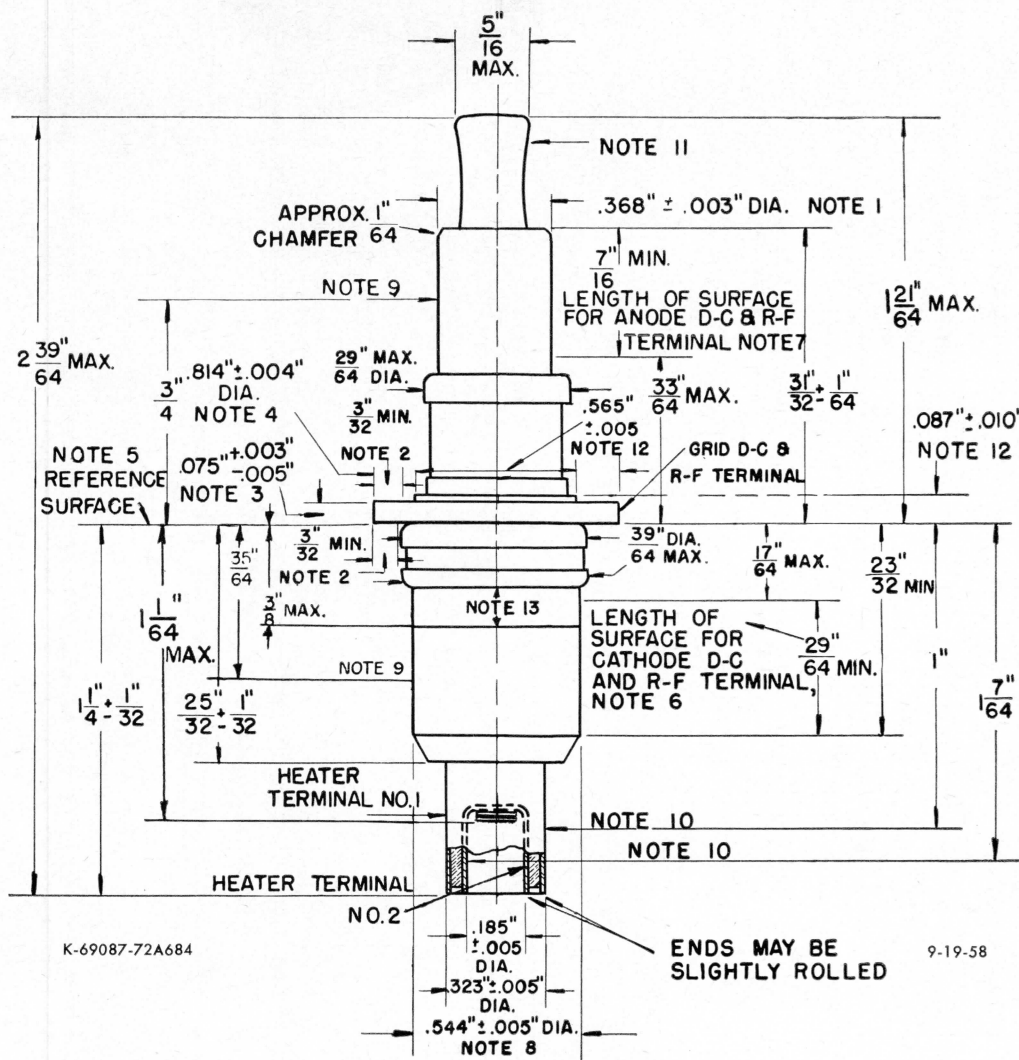
* The correct value of heater voltage is dependent upon the particular operating conditions and frequency. For the recommended value, consult the Power Tube Department, Schenectady 5, N. Y. The value recommended should be maintained within 5 percent for satisfactory life and performance.

CONSTANT-CURRENT CHARACTERISTICS

$E_f = 6.3$ Volts

Electrode Voltages Measured with Respect to Cathode





- Note 1. Applies to minimum surface for anode d-c and r-f terminal only. Other surfaces must not be used for these terminal purposes.
- Note 2. Applies to minimum surface for grid d-c and r-f terminal only. Other surfaces, except for Notes 3 and 4, must not be used for terminal purposes.
- Note 3. Applies to minimum surfaces for grid d-c and r-f terminal only.
- Note 4. The cylindrical surface of this diameter may be used for grid d-c and r-f terminal purposes.
- Note 5. The surfaces defined by Notes 2, 3, and 4 must be the only surfaces used for tube stops and clamping purposes.
- Note 6. Other surfaces must not be used for cathode d-c and r-f terminal purposes.
- Note 7. Other surfaces must not be used for anode d-c and r-f terminal purposes.
- Note 8. Applies to surface designated for cathode d-c and r-f terminal. Solder at brazed joint will not exceed the maximum diameter.
- Note 9. The maximum eccentricity of the anode and cathode with respect to the grid terminal in a prescribed jig is 0.010 (or maximum total runout of 0.020) and is measured by indicators at the points designated.
- Note 10. The maximum eccentricity of heater-terminal No. 1 and heater-terminal No. 2 with respect to the grid terminal in a prescribed jig is 0.015 (or maximum total runout of 0.030) and is measured by indicators at the points designated.
- Note 11. Exhaust tabulation must not be subjected to any mechanical stress.
- Note 12. For reference only. Dimension does not include any possible solder fillet.
- Note 13. This area is reserved for tube stamping and coding.

ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
Schenectady 5, N. Y.

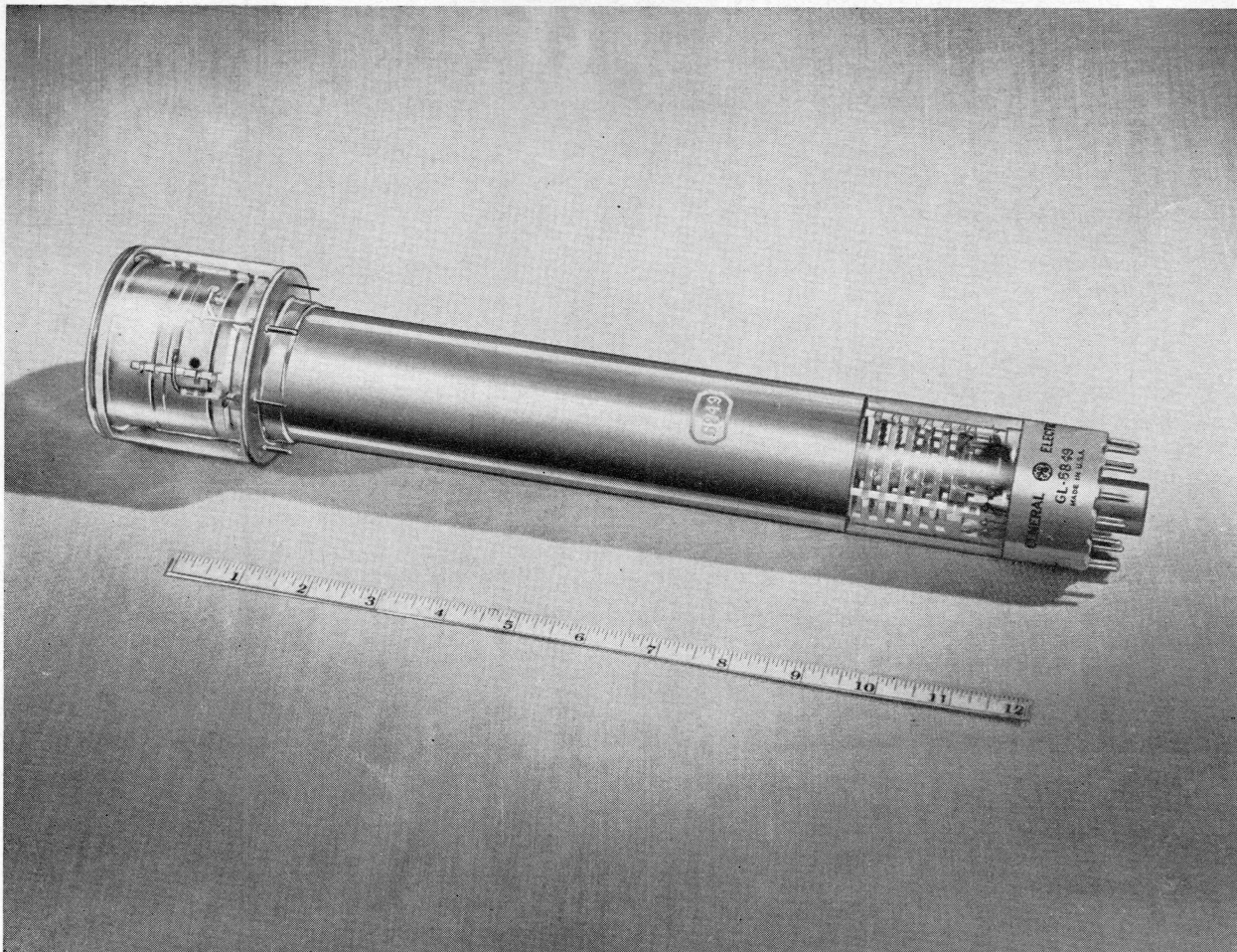


IMAGE ORTHICON

MAGNETIC FOCUS

MAGNETIC DEFLECTION

LOW-LIGHT-LEVEL PICKUP

The GL-6849 is a television camera tube for extremely low-light-level pickup use. Typical applications are observation of fluoroscopic screens, scenes illuminated by starlight and direct images of stars.

Extremely wide target-to-mesh spacing reduces smearing or lag of moving images at low light levels by better beam modulation. This results in an increase in signal-to-noise ratio at low illumination levels. Wide spacing eliminates microphonics orig-

inating in the target-mesh assembly.

The GL-6849 photocathode is characterized by a spectral response with high blue and high green sensitivity, very good yellow sensitivity and good red sensitivity. It has practically no infra-red sensitivity. This characteristic of the response permits portrayal of colors in nearly their true tonal gradation since it prevents any color-masking by infra-red.

TECHNICAL INFORMATION

GENERAL

Electrical

Cathode—Unipotential

Heater Voltage, AC or DC.....6.3 $\pm$ 10% Volts

Heater Current.....0.6 Amperes

Photocathode—Semi-transparent

Response—See spectral sensitivity curve on page 3 for details.

Rectangular Image, 4 by 3 aspect ratio

Useful Size, maximum diagonal.....1.8 Inches

Orientation—Proper orientation is obtained when the vertical scan is essentially parallel to the plane passing through the center of the faceplate and pin No. 7 of the shoulder base.

Focusing Method—Magnetic

Deflecting Method—Magnetic

Direct Interelectrode Capacitance

Anode to All Other Electrodes.....12 μ f

TECHNICAL INFORMATION (CONT'D)

Mechanical

Over-all Length.....	15.20" $\pm$ 0.25"	Inches
Greatest Diameter of Bulb.....	3.00" $\pm$ 0.06"	Inches
Minimum Deflecting Coil Inside Diameter.....	2 $\frac{3}{8}$	Inches
Deflecting Coil Length.....	5	Inches
Focusing Coil Length.....	10	Inches
Alignment Coil Length.....	1 $\frac{5}{8}$	Inches
Photocathode Distance Inside End of Focusing Coil.....	1 $\frac{1}{2}$	Inches
Weight, approximate.....	1.4	Pounds
Operating Position—Any, except with diheptal base up and the tube axis at an angle of less than 20 degrees from vertical.		

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Maximum Ratings, Absolute Values

Photocathode Voltage.....	—550 Max	Volts
Photocathode Illumination.....	50 Max	Foot-Candles
Anode Supply Voltage*.....	1350 Max	Volts
Grid-No. 1 Voltage		
Negative Bias Value.....	125 Max	Volts
Positive Bias Value.....	0 Max	Volts
Grid-No. 2 and Dynode-No. 1 Voltage.....	350 Max	Volts
Grid-No. 3 Voltage.....	400 Max	Volts
Grid-No. 4 Voltage.....	300 Max	Volts
Grid-No. 5 Voltage.....	150 Max	Volts
Grid-No. 6 Voltage.....	—550 Max	Volts
Voltage Per Multiplier Stage.....	350 Max	Volts
Target Voltage		
Positive Value.....	10 Max	Volts
Negative Value.....	10 Max	Volts
Peak Heater-Cathode Voltage		
Heater Negative with Respect to Cathode.....	125 Max	Volts
Heater Positive with Respect to Cathode.....	10 Max	Volts
Operating Temperature of Any Part of Bulb.....	50 Max	C
Operating Temperature of Bulb at Large End of Tube, target section.....	35 Min	C
Temperature Difference		
Between Target Section and Any Part of Bulb Hotter Than Target Section.....	5 Max	C

Typical Operation

Photocathode Voltage, image focus.....	—400 to —540	Volts
Grid-No. 1 Voltage for Picture Cut-off, beam.....	—45 to —115	Volts
Grid-No. 2 and Dynode-No. 1 Voltage.....	300	Volts
Grid-No. 3 Voltage†, multiplier focus.....	225 to 330	Volts
Grid-No. 4 Voltage, beam focus.....	140 to 180	Volts
Grid-No. 5 Voltage, decelerator.....	0 to 125	Volts
Grid-No. 6 Voltage, accelerator		
75 Percent of Photocathode Voltage, approximate.....	—300 to —405	Volts
Dynode-No. 2 Voltage.....	600	Volts
Dynode-No. 3 Voltage.....	800	Volts
Dynode-No. 4 Voltage.....	1000	Volts
Dynode-No. 5 Voltage.....	1200	Volts
Anode Voltage.....	1250	Volts
DC Anode Current.....	3	Microamperes
Signal Output Current, peak to peak.....	0.01 to 5	Microamperes
Target Voltage‡		
Target Cutoff Voltage‡.....	—3 to +1	Volts
Blanking Voltage, peak to peak.....	5 to 20	Volts
Target Temperature Range.....	35 to 45	C
Ratio of Peak-to-Peak Highlight Video Signal		
Current to RMS Noise Current, approximate.....	35	
Minimum Peak-to-Peak Blanking Voltage.....	5	Volts
Field Strength at Center of Focusing Coil§.....	75	Gausses
Field Strength of Alignment Coil, approximate.....	0 to 3	Gausses

* Ratio of dynode voltages is shown under Typical Operation.

† Adjust to give the most uniformly shaded picture near maximum signal.

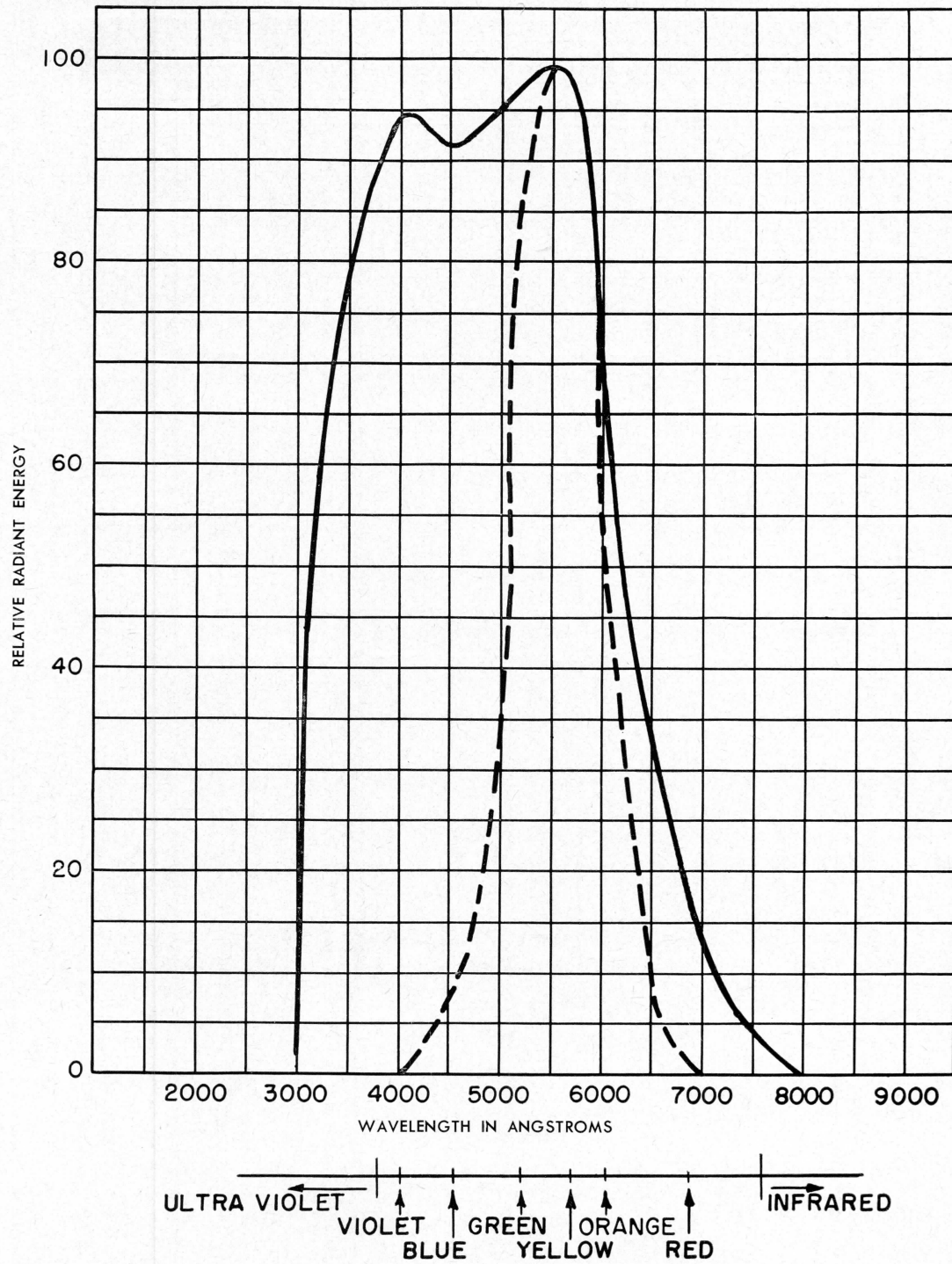
‡ Adjustable from —3 to +5 volts with blanking voltage off. Normal setting of target voltage is +2 volts from target cutoff.

§ Direction of current should be such that a north-seeking pole is attracted to the image end of the focusing coil, with the indicator located outside of and at the image end of the focusing coil.

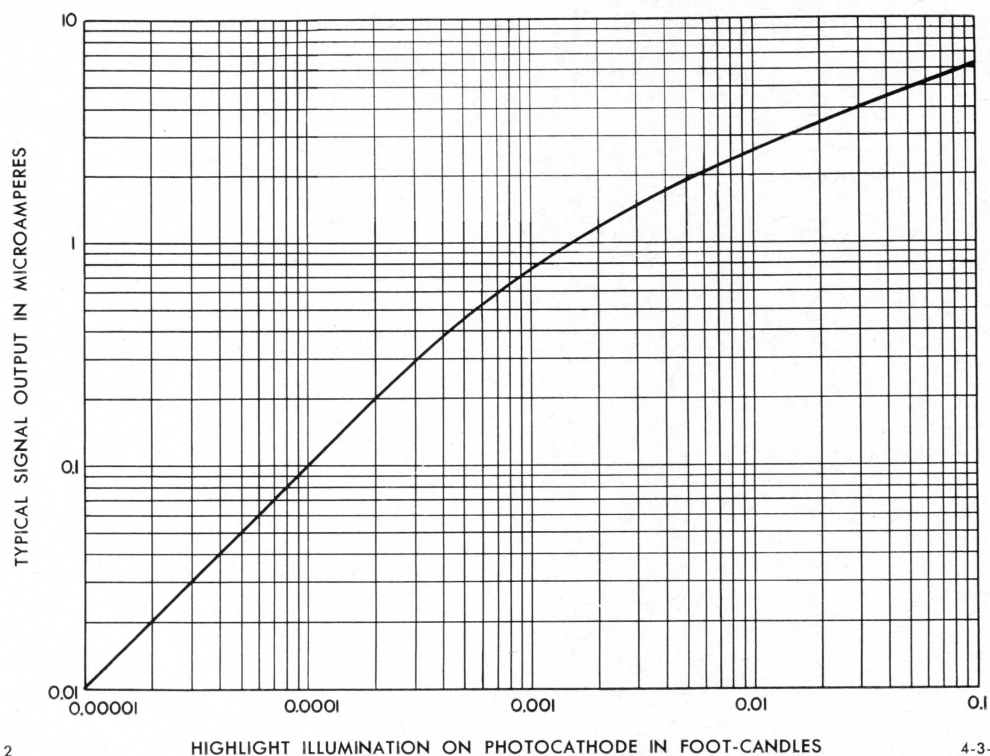
⊕ Denotes a change.

□ Denotes an addition.

SPECTRAL SENSITIVITY CHARACTERISTIC
FOR EQUAL VALUES OF RADIANT FLUX AT ALL WAVELENGTHS
DASHED CURVE SHOWS SPECTRAL CHARACTERISTIC OF AVERAGE HUMAN EYE



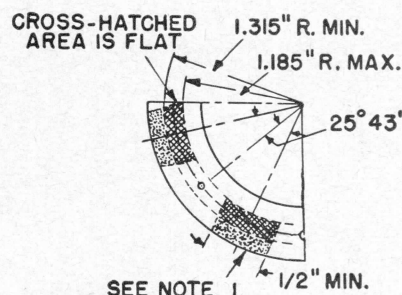
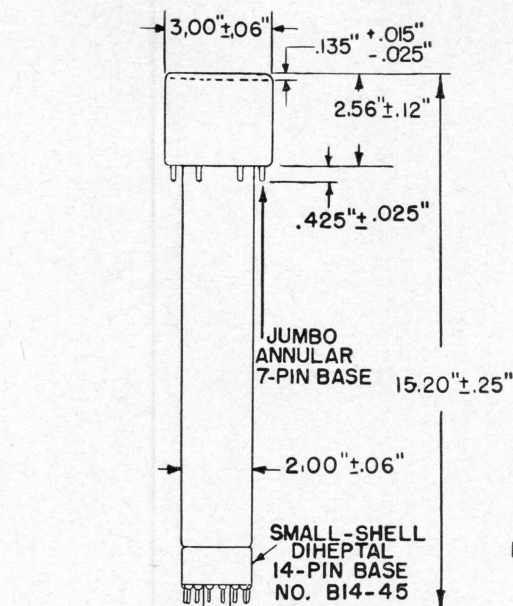
TYPICAL SIGNAL OUTPUT
SCENE: BLACK AND WHITE BALANCED
TUNGSTEN, DAYLIGHT, OR WHITE FLUORESCENT LIGHT



K-69087-262A12

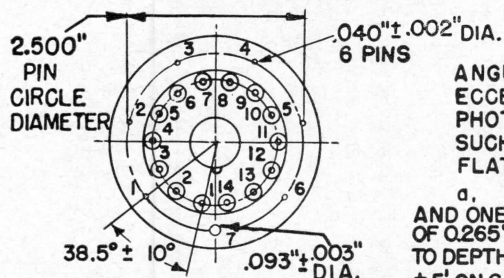
HIGHLIGHT ILLUMINATION ON PHOTOCATHODE IN FOOT-CANDLES

4-3-57



DETAIL OF BOTTOM VIEW OF JUMBO ANNULAR BASE

NOTE 1: DOTTED AREA IS FLAT OR EXTENDS TOWARD DIHEPTAL-BASE END OF TUBE BY 0.060" MAX.

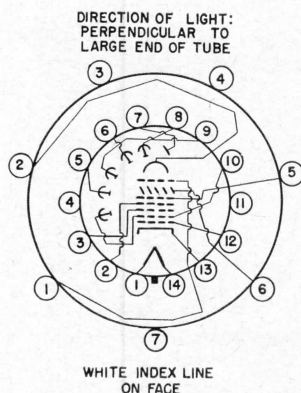


ENLARGED BOTTOM VIEW

ANNULAR BASE GAGE

ANGULAR VARIATIONS BETWEEN PINS AS WELL AS ECCENTRICITY OF NECK CYLINDER WITH RESPECT TO PHOTOCATHODE CYLINDER ARE HELD TO TOLERANCES SUCH THAT PINS AND NECK CYLINDER WILL FIT FLAT-PLATE GAGE WITH:

- a. SIX HOLES HAVING DIAMETER OF 0.065 ± 0.001 " AND ONE HOLE HAVING DIA. OF 0.150 ± 0.001 ". ALL HOLES HAVE DEPTH OF 0.265 ± 0.001 ". THE SIX 0.065 " HOLES ARE ENLARGED BY 45° TAPER TO DEPTH OF 0.047 ". ALL HOLES ARE SPACED AT ANGLES OF $51^\circ 26' \pm 5'$ ON CIRCLE DIAMETER OF 2.500 ± 0.001 ".
- b. SEVEN STOPS HAVING HEIGHT OF 0.187 ± 0.001 ", CENTERED BETWEEN PIN HOLES, TO BEAR AGAINST FLAT AREAS OF BASE.
- c. RIM EXTENDING OUT A MINIMUM OF 0.125 " FROM 2.812 " DIAMETER AND HAVING HEIGHT OF 0.126 ± 0.001 ".
- d. NECK-CYLINDER CLEARANCE HOLE HAVING DIAMETER OF 2.200 ± 0.001 ".



BASING DIAGRAM

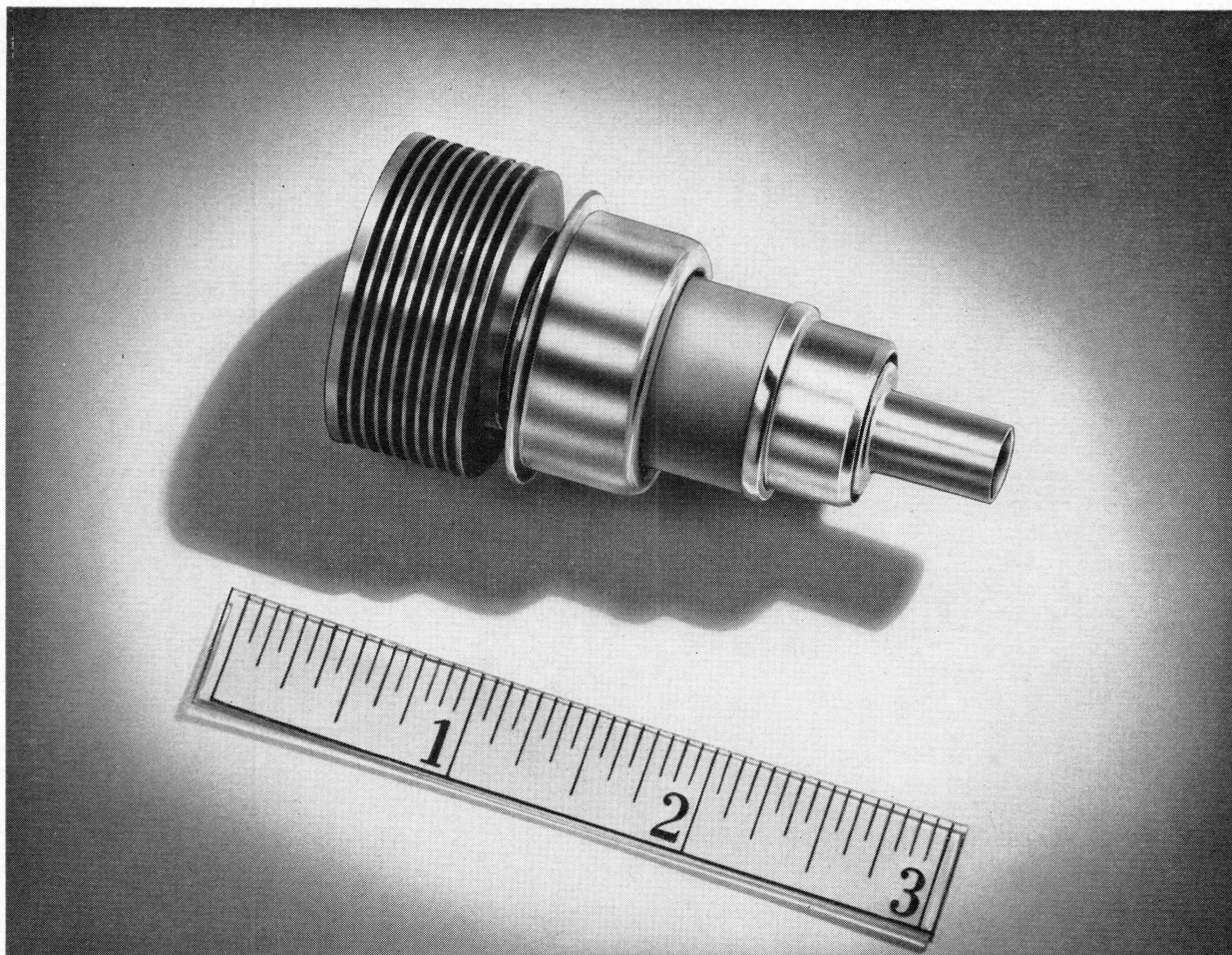
SMALL-SHELL DIHEPTAL 14-PIN BASE

PIN 1: HEATER	PIN 6: DYNODE NO. 4	PIN 11: INTERNAL CONNEC-
PIN 2: GRID NO. 4	PIN 7: ANODE	TION-DO NOT USE
PIN 3: GRID NO. 3	PIN 8: DYNODE NO. 5	PIN 12: GRID NO. 1
PIN 4: INTERNAL CONNEC-	PIN 9: DYNODE NO. 3	PIN 13: CATHODE
TION-DO NOT USE	PIN 10: DYNODE NO. 1,	PIN 14: HEATER
PIN 5: DYNODE NO. 2	GRID NO. 2	

KEYED JUMBO ANNULAR 7-PIN BASE

PIN 1: GRID NO. 6	PIN 5: GRID NO. 5
PIN 2: PHOTOCATHODE	PIN 6: TARGET
PIN 3: INTERNAL CONNEC-	PIN 7: INTERNAL CONNEC-
TION-DO NOT USE	TION-DO NOT USE
PIN 4: INTERNAL CONNEC-	
TION-DO NOT USE	

ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
Schenectady 5, N. Y.



TRIODE

**VHF-UHF
SINGLE-ENDED
LOW LEAD INDUCTANCE
HIGH TEMPERATURE**

**METAL AND CERAMIC
HIGH SHOCK RESISTANCE
LOW INTERELECTRODE CAPACITANCES
TIGHT TOLERANCES**

The GL-6897 is a high- μ triode for use at very-high and ultra-high frequencies in grounded-grid Class C power-amplifier, oscillator, or frequency-multiplier circuits. In such service it will operate from the low frequencies to those as high as 2900 megacycles. The anode can dissipate 100 watts with forced-air cooling of the radiator through a suitable cowling. Cooling of the tube envelope is accomplished by conduction from the contact circuit members with sufficient additional forced air to limit the maximum temperature to 250 C.

The tube has an oxide-coated indirectly heated cathode of planar-electrode construction. The

metal-and-ceramic envelope holds concentricity to limits previously thought impossible. The inherent strength of the structural design allows shock testing at 400 g. Graduated-diameter disk seals, typical of the General Electric lighthouse tube, assure maximum efficiency in the use of cavity and parallel-line circuits with the resultant desirable features of both low lead inductances and electrode isolation. Radio-frequency losses in the tube are kept to a minimum by the special techniques and materials used. Other features of the tube are high transconductance and low interelectrode capacitances.

GENERAL  ELECTRIC

Supersedes ET-T1303A dated 9-57

TECHNICAL INFORMATION

GENERAL

Electrical

Cathode—Indirectly Heated

Heater Voltage, dependent upon operating conditions†	6.3	Volts
Heater Current	1.05	Amperes
Cathode Heating Time, minimum	1.0	Minutes

	Minimum	Bogey	Maximum	
☐ Transconductance, $I_p = 75$ ma, $E_p = 600$ volts	22,000	24,800	27,500	Micromhos
☐ Amplification Factor	75	95	115	
Direct Interelectrode Capacitances				
With External Shield, Heater Voltage = 0 volts				
☐ Grid to Plate	1.89	2.01	2.13	$\mu\mu f$
☐ Grid to Cathode	6.0	6.5	7.00	$\mu\mu f$
☐ Plate to Cathode, maximum	0.018	0.023	0.029	$\mu\mu f$
Frequency			2500	Megacycles

Mechanical

Mounting Position—Any

Only Anode Flange to be Used as a Socket Stop and Clamp

Net Weight, approximate	2	Ounces
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Thermal

Cooling

Anode and Anode Seal—Conduction and Forced Air

Grid and Cathode Seals—Conduction and Forced Air

Recommended Air Flow Cowling—157-JAN

Recommended Air Flow on Anode Radiator at Sea Level

Incoming Air Temperature 25 C; Plate Dissipation 100 Watts	12.5	Cubic Feet per Minute
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Maximum Temperature of Any Seal Under Any Conditions*	250	C
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MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

Key-Down Conditions Per Tube Without Amplitude Modulation

Maximum Ratings, Absolute Values

Heater Voltage—Dependent Upon Operating Conditions†

DC Plate Voltage	1000	Volts
DC Cathode Current	125	Milliamperes
DC Grid Voltage	-150	Volts
DC Grid Current	50	Milliamperes
Peak Positive RF Grid Voltage	30	Volts
Peak Negative RF Grid Voltage	-400	Volts
Plate Dissipation	100	Watts
Grid Dissipation	2	Watts

Typical Operation—Key-Down Conditions

Class C Oscillator, grid-return circuit

Frequency	500	2500	Megacycles
Heater Voltage†			
DC Plate Voltage	900	900	Volts
DC Plate Current	90	90	Milliamperes
DC Grid Current	30	27	Milliamperes
DC Grid Voltage	-40	-22	Volts
Useful Power Output	40	17	Watts

TECHNICAL INFORMATION (CONT'D)

RADIO-FREQUENCY POWER AMPLIFIER OR OSCILLATOR, PLATE-MODULATED—CLASS C TELEPHONY

Carrier Conditions For Use With A Maximum Modulation Factor Of 1.0

Maximum Ratings, Absolute Values

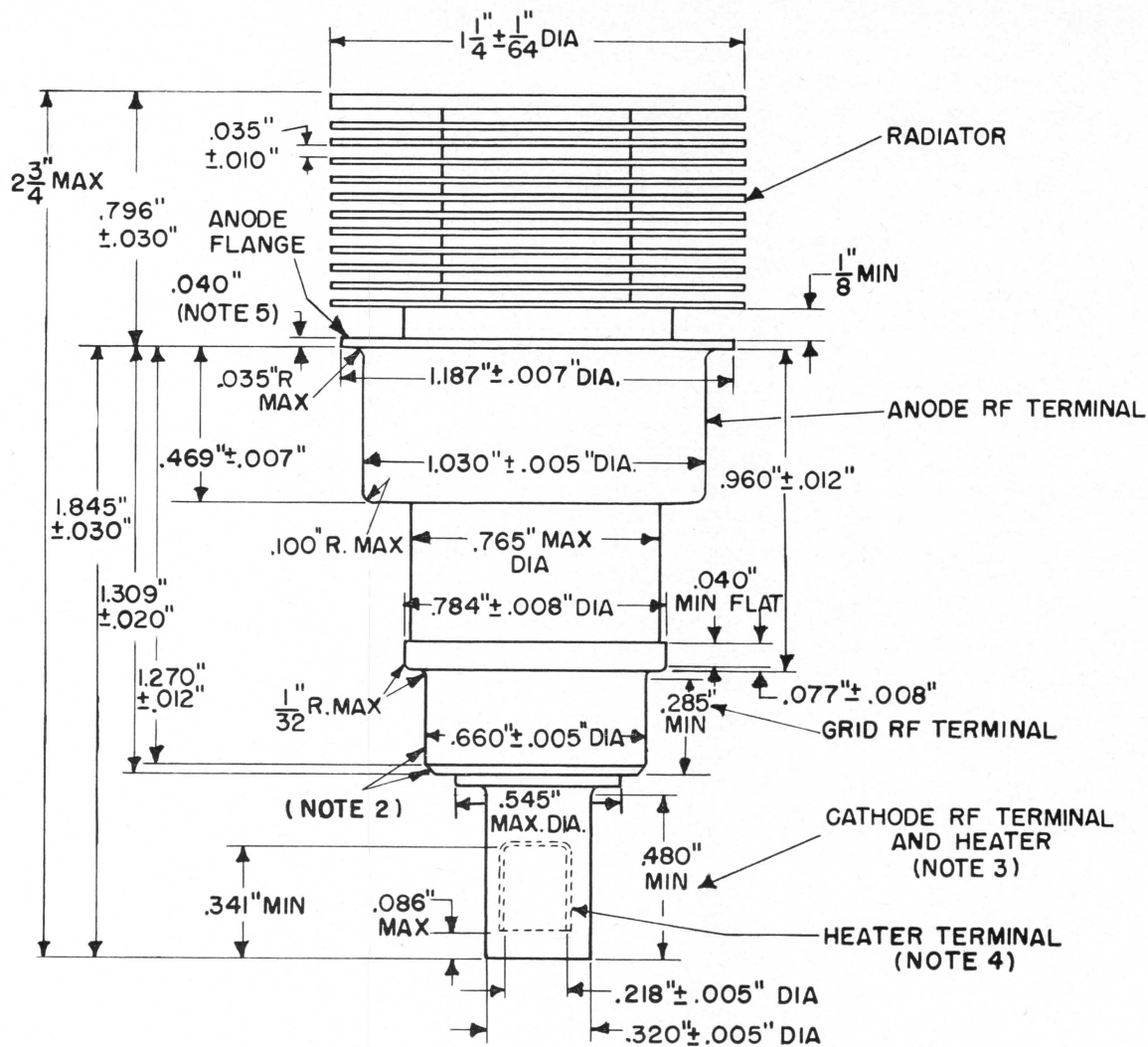
Heater Voltage, dependent upon operating conditions†	
DC Plate Voltage‡	600 Volts
DC Cathode Current	100 Milliamperes
DC Grid Voltage	-150 Volts
DC Grid Current	50 Milliamperes
Peak Positive RF Grid Voltage	30 Volts
Peak Negative RF Grid Voltage	-400 Volts
Plate Dissipation	70 Watts
Grid Dissipation	2 Watts

* Where long life and reliable operation are important, lower tube envelope temperatures should be used.

† The GL-6897 operates at frequencies where it is necessary to consider transit-time effects of the electron current. The principal effects influencing tube operation are the decrease in power output and operating efficiency with increase in frequency, and the bombardment and heating of the cathode by electrons from the region of the grid which can be severe enough to result in short tube life and erratic operation. Operating frequency, circuit design and adjustment, grid bias, and grid current contribute to the degree of cathode bombardment. There is an optimum heater voltage which will maintain the cathode at the correct operating temperature for a particular set of operating conditions. If the conditions of operation result in appreciable cathode back heating, it may be necessary to start dynamic tube operation at normal heater voltage followed by a reduction of heater voltage to the proper value. A maximum variation of plus or minus five percent in heater voltage is recommended where extended tube life is a factor. Under all other conditions, the variation in heater voltage should not exceed plus or minus ten percent. For application above 400 megacycles, recommendations are to be obtained from the tube manufacturer regarding the heater voltage to be used under a specific set of operating conditions.

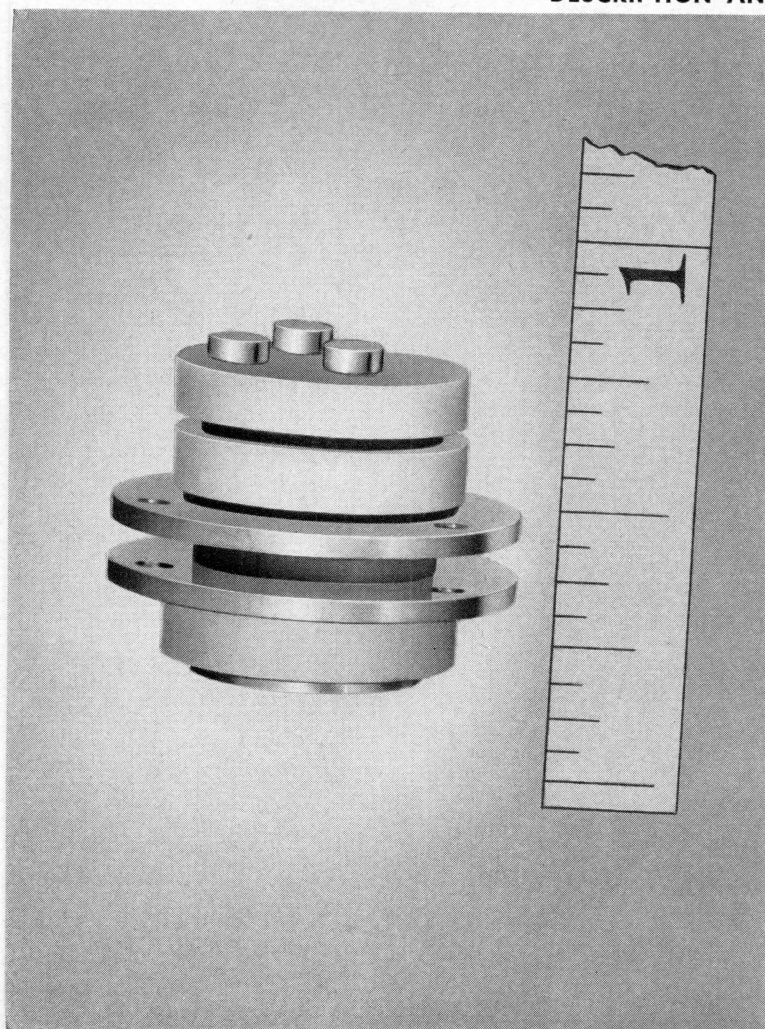
‡ For modulation factors less than 1.0 a higher d-c plate voltage may be used if the sum of the peak positive audio voltage and the d-c plate voltage does not exceed 1200 volts.

□ Denotes a change.



NOTES:

1. External metal parts (except radiator) plated with 30 msi of copper and /or silver.
2. Solder not to extend radially beyond grid RF terminal.
3. Total indicated runout of the grid-contact surface and the cathode-contact surface with respect to the anode shall not exceed 0.020"
4. Total indicated runout of the cathode-contact surface with respect to the heater-contact surface shall not exceed 0.012"
5. Only this flange to be used as a socket stop and clamp.



VOLTAGE-TUNABLE MAGNETRON

METAL AND CERAMIC

POWER OUTPUT—10 WATTS

2000-4000 MEGACYCLES

VOLTAGE-TUNED OVER FREQUENCY RANGE

The GL-6917 is a CW interdigital voltage-tunable magnetron for operation in the 2000-to-4000-megacycle range. In a narrow-band circuit, this tube has a power output up to 10 watts. In a circuit covering 2000 to 4000 megacycles, it has a power output up to 1.0 watt.

A novel ceramic-to-metal seal construction results in a tube extremely small in size—less than $\frac{5}{8}$ inch long and less than $\frac{3}{4}$ inch in diameter—

and one which is especially designed for operation at microwave frequencies.

The GL-6917, in an external r-f circuit, may be voltage-tuned over a portion or all of the frequency range for which it is designed. The frequency of the generated signal is a linear function of the anode voltage. The r-f power output at any frequency is a function of the impedance of the external r-f circuit.

GENERAL  ELECTRIC

GENERAL

Electrical

	Minimum	Bogey	Maximum	
Cathode—Directly Heated				
Filament Voltage*	2.0	2.25	2.5	Volts
Filament Current*	...	3.0	...	Amperes
Direct Interelectrode Capacitances				
Anode to Anode, approximate	...	4.9	...	$\mu\mu\text{f}$
Both Anodes to Filament, approximate	...	1.3	...	$\mu\mu\text{f}$
Both Anodes to Injection Electrode, approximate	...	2.9	...	$\mu\mu\text{f}$
Both Anodes to Cold Cathode, approximate	...	3.3	...	$\mu\mu\text{f}$

Mechanical

Mounting Position—Any

Thermal

Type of Cooling—Forced Air

Envelope Temperature, maximum.....150 C

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Maximum Ratings, Absolute Values

Anode Voltage	2500	Volts
Anode Current	40	Milliamperes
Power Input, with forced-air cooling	60	Watts
Injection Electrode Voltage	500	Volts
Injection Electrode Current	1.0	Milliamperes
Filament Current	3.2	Amperes
Voltage Standing Wave Ratio	1.5	

Typical Operating Conditions

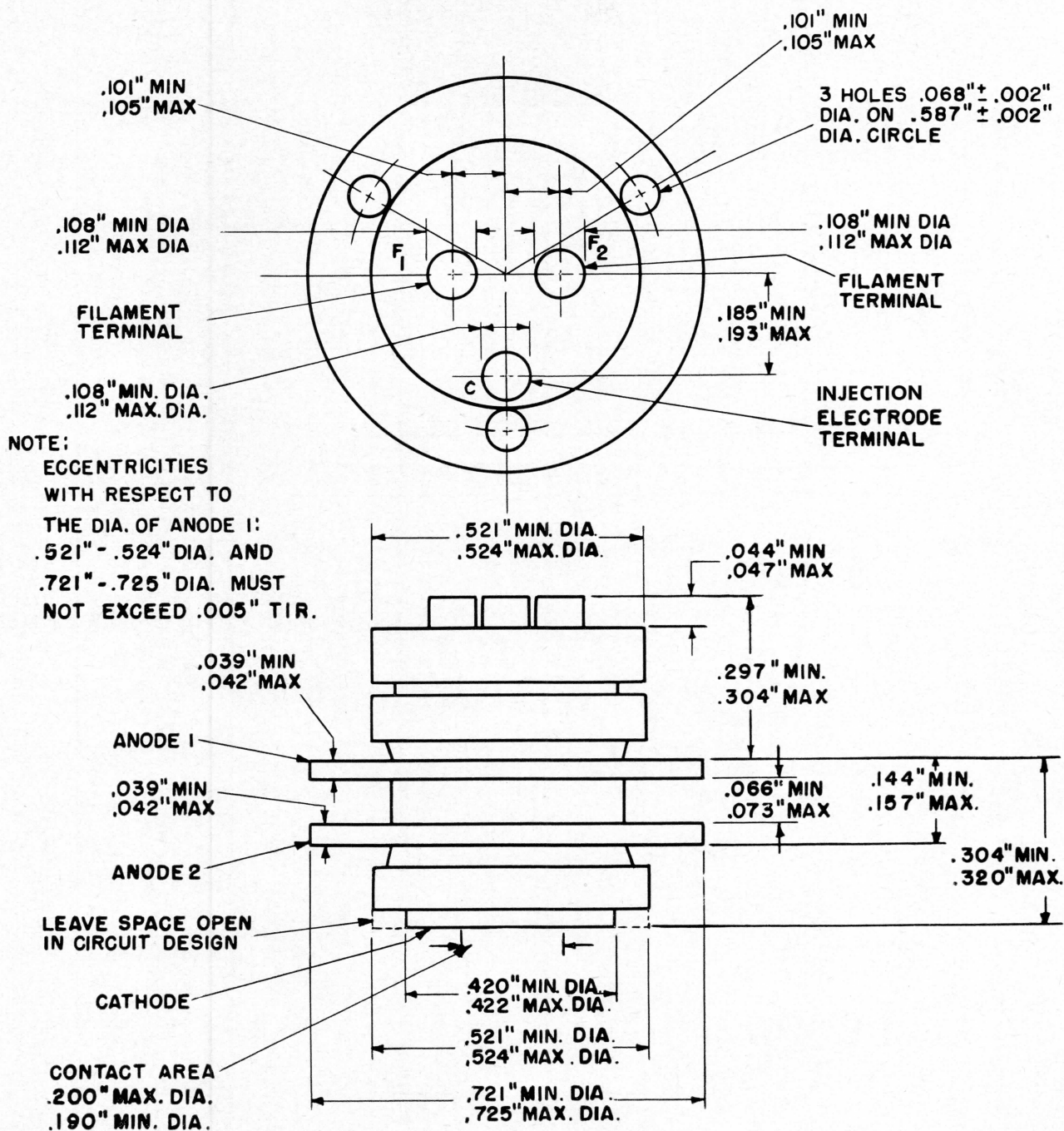
Operation with 60-Cycle Sweep Voltage in a Wide-Band Circuit

Tunable Range†	2000 to 4000	Megacycles
Magnetic Field Strength‡	2500 $\pm$ 50	Gausses
Tuning Rate, approximate	3.0	Megacycles per Volt
Filament Voltage, approximate*	2.25	Volts
Filament Current*	3.0	Amperes
Anode Voltage at 3 Kilomegacycles, 2500 gaussess	1150	Volts
Anode Current, average	10 to 20	Milliamperes
Injection Electrode Voltage, positive with respect to cathode	300 to 500	Volts
Injection Electrode Current	0.1	Milliamperes
Voltage Standing Wave Ratio	1.3	
Power Output, average	0.5 to 1.0	Watts

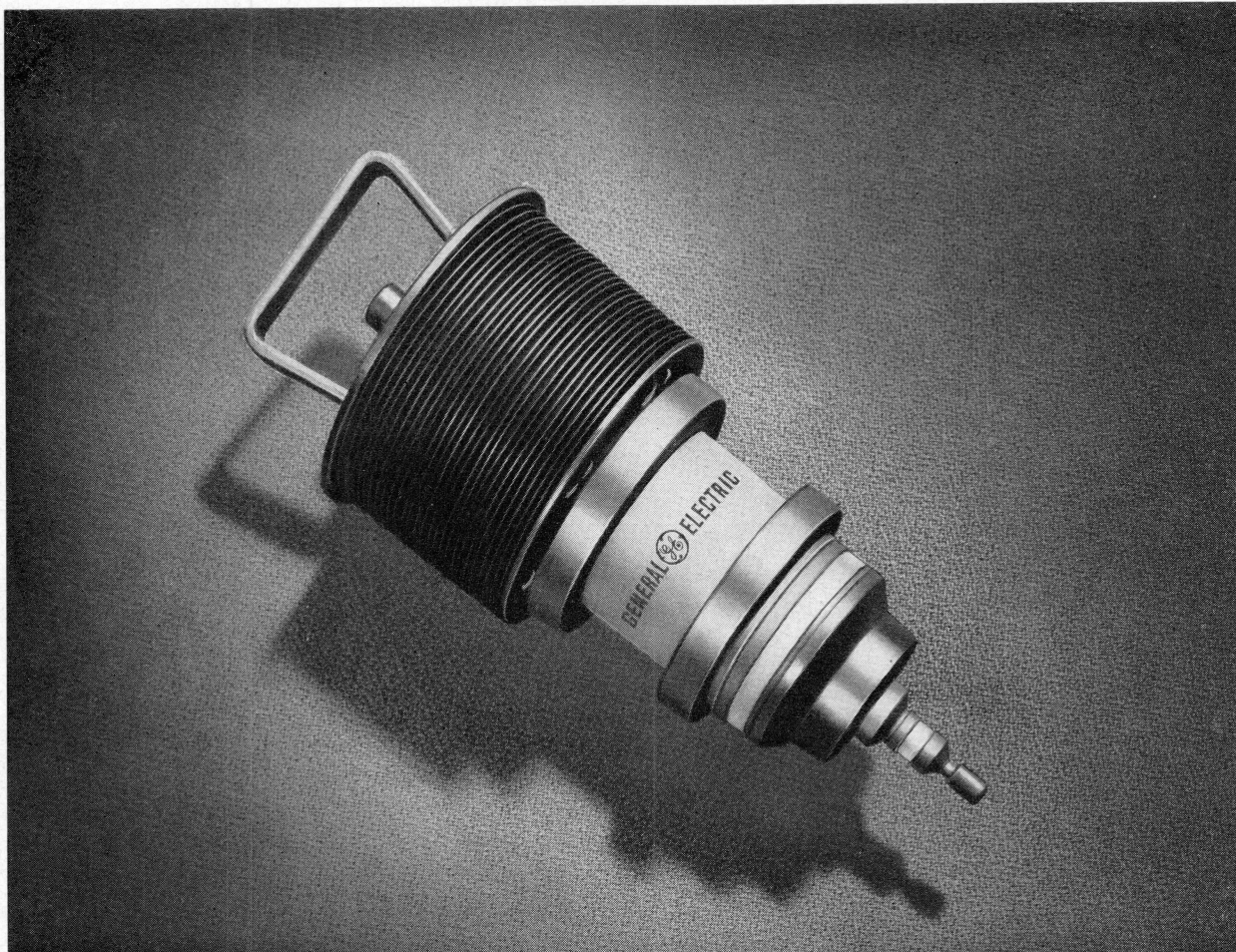
* Filament current should be adjusted to 3.0 amperes.

† Frequency controlled by anode voltage.

‡ An "E" shaped, nylon-coated magnet is available from the tube manufacturer. Other magnets can be used, provided they can supply a uniform field of 2500 gaussess across an air gap at least $\frac{7}{8}$ inch long and $\frac{1}{16}$ inch in diameter. The tube will operate satisfactorily between 2000 and 3000 gaussess with some change of characteristics. In general, increasing the magnetic field will increase the power-output, efficiency, and the anode voltage for constant frequency and decrease the tuning rate.



ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
Schenectady 5, N. Y.



TETRODE

ONE KILOWATT UHF TELEVISION OUTPUT

UHF TETRODE

GROUND-GRID CIRCUITS

FORCED-AIR COOLED

METAL AND CERAMIC

INTEGRAL RADIATOR

THORIATED-TUNGSTEN CATHODE

The GL-6942 is a four-electrode transmitting tube featuring a metal-and-ceramic envelope designed for use as a power amplifier or oscillator in grounded-grid circuits with both grids maintained at radio-frequency ground potential. The output circuit is connected between the anode and the screen grid. The anode is capable of dissipating one and one-half kilowatts. Cooling is accomplished by forced air with the radiator an integral part of the anode. The cathode is indirectly heated thoriated tungsten. Maximum ratings apply up to 900 megacycles.

When used as a Class B grounded-grid broadband television amplifier this tube has a useful synchronizing peak-power output of one kilowatt

at 900 megacycles; in narrow band Class C service the output is one kilowatt of continuous power as an amplifier or oscillator. Because of its ratings, the tube is also well adapted to use in dielectric-heating equipment.

High operating efficiency is assured because of the small size and close spacing of the tube electrodes, the ring-seal construction, and the low-loss factor due to the silver-plated external parts and the ceramic insulators. In addition, the grounded-grid construction eliminates the necessity for neutralization in a properly designed circuit. The small size of the GL-6942 permits compact mounting, and the ring-seal construction allows quick plug-in installation.

GENERAL  ELECTRIC

#Supersedes pages 1 and 2 dated 9-57

TECHNICAL INFORMATION

GENERAL

Electrical

	Minimum	Bogey	Maximum	
Heater Voltage*		5.7	6.0	Volts
Heater Current at 5.7 Volts	22	24	26	Amperes
Heater Starting Current			36	Amperes
Heater Cold Resistance		0.02		Ohms
Cathode Heating Time	1			Minutes
Amplification Factor, G_2 to G_1				
$\oplus E_b = 2000$ Volts, $I_b = 0.200$ Ampere, $E_c = 475$ Volts	12	17	22	
Peak Cathode Current†			3.0	Amperes
Direct Interelectrode Capacitances				
Cathode to Plate‡			0.006	$\mu\mu\text{f}$
Input, G_2 tied to G_1	15.5	17.0	18.5	$\mu\mu\text{f}$
Output, G_2 tied to G_1 §	5.0	5.5	6.0	$\mu\mu\text{f}$

Mechanical

Mounting Position—Vertical

Net Weight, approximate 3.6 Pounds

Thermal

Air Flow¶

Through Radiator—See drawing for air duct form on page 4.

Plate Dissipation	1.5	Kilowatts
Air Flow	.60 Min	Cubic Feet per Minute
Static Pressure	1.5	Inches Water
Heater-to-Cathode Seals	.8 Min	Cubic Feet per Minute
Screen-Grid to Control-Grid Seals	.4 Min	Cubic Feet per Minute
Anode to Screen-Grid Ceramic Insulator	.6 Min	Cubic Feet per Minute
Incoming Air Temperature	.45 Max	C
Radiator Hub Temperature at Fin Adjacent to Anode Seal	180 Max	C
Ceramic Temperature at Any Point	200 Max	C

Forced-air cooling to be applied before and during the application of any voltages. Forced-air cooling must be maintained for one minute after the removal of all voltages.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

RADIO-FREQUENCY AMPLIFIER—CLASS B TELEVISION SERVICE

Synchronizing-Level Conditions per Tube Unless Otherwise Specified

Maximum Ratings, Absolute Values

DC Plate Voltage	4000 Max	Volts
DC Grid-No. 2 Voltage	600 Max	Volts
DC Plate Current	0.7 Max	Amperes
Plate Input	2.5 Max	Kilowatts
Grid-No. 2 Input	.25 Max	Watts
Plate Dissipation	1.5 Max	Kilowatts

Typical Operation—Grounded-Grid Circuit up to 900 Megacycles

Bandwidth 6 Megacycles, measured to 1 decibel point

DC Plate Voltage	3500	Volts
DC Grid-No. 2 Voltage	500	Volts
DC Grid-No. 1 Voltage	—40	Volts
Peak RF Plate Voltage		
Synchronizing Level	2500	Volts
Pedestal Level	1875	Volts
Peak RF Driving Voltage		
Synchronizing Level	110	Volts
Pedestal Level	70	Volts
DC Plate Current		
Synchronizing Level	0.520	Amperes
Pedestal Level	0.360	Amperes
DC Grid-No. 2		
Pedestal Level	0.035	Amperes
DC Grid-No. 1 Current		
Synchronizing Level	0.110	Amperes
Pedestal Level	0.035	Amperes

TECHNICAL INFORMATION (CONT'D)

Driving Power at Tube, approximate		
Synchronizing Level	100	Watts
Pedestal Level	25	Watts
Power Output, approximate ϕ		
Synchronizing Level	1000	Watts
Pedestal Level	560	Watts

PLATE-MODULATED RADIO-FREQUENCY POWER AMPLIFIER—CLASS C TELEPHONY

Carrier Conditions with a Maximum Modulation Factor of 1.0

Maximum Ratings, Absolute Values

DC Plate Voltage	3200 Max	Volts
DC Grid-No. 2 Voltage	600 Max	Volts
DC Grid-No. 1 Voltage	-120 Max	Volts
DC Plate Current	0.35 Max	Amperes
DC Grid-No. 1 Current	0.10 Max	Amperes
Plate Input	1.12 Max	Kilowatts
Grid-No. 2 Input	10 Max	Watts
Plate Dissipation	1200 Max	Watts

Typical Operation, Grounded-Grid Circuit up to 900 Megacycles

DC Plate Voltage	3000	Volts
DC Grid-No. 2 Voltage	500	Volts
DC Grid-No. 1 Voltage	-100	Volts
Peak RF Plate Voltage	2300	Volts
Peak RF Driving Voltage	137	Volts
DC Plate Current	0.25	Amperes
DC Grid-No. 2 Current	0.01	Amperes
DC Grid-No. 1 Current, approximate	0.047	Amperes
Driving Power, approximate $\diamond$	38	Watts
Power Output ϕ	565	Watts

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

Key-Down Conditions per Tube without Amplitude Modulation $\blacktriangle$

Maximum Ratings, Absolute Values

DC Plate Voltage	4000 Max	Volts
DC Grid-No. 2 Voltage	600 Max	Volts
DC Grid-No. 1 Voltage	-150 Max	Volts
DC Plate Current	0.7 Max	Amperes
DC Grid-No. 1 Current	0.10 Max	Amperes
Plate Input	2.5 Max	Kilowatts
Grid-No. 2 Input	25 Max	Watts
Plate Dissipation	1.5 Max	Kilowatts

Typical Operation—Grounded-Grid Circuit up to 900 Megacycles

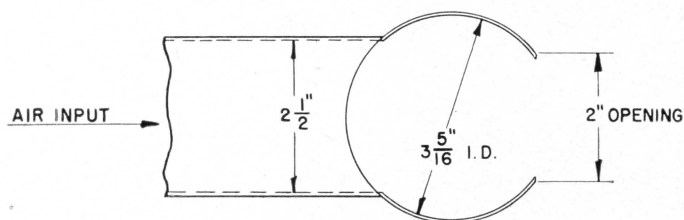
DC Plate Voltage	3800	Volts
DC Grid-No. 2 Voltage	500	Volts
DC Grid-No. 1 Voltage	-120	Volts
Peak RF Plate Voltage, approximate	2750	Volts
Peak RF Grid-No. 1 Voltage	195	Volts
DC Plate Current	0.500	Amperes
DC Grid-No. 2 Current	0.022	Amperes
DC Grid-No. 1 Current, approximate	0.075	Amperes
Driving Power, approximate	150	Watts
Power Output, approximate $\heartsuit$	1200	Watts

* The cathode of the GL-6942 because of transit-time effects which raise the temperature of the cathode, is subjected to considerable back bombardment in ultra-high-frequency service. The amount of heating due to bombardment is a function of the operating conditions and frequency, and must be compensated for by a reduction of the heater input to prevent overheating of the cathode with resulting short life. For long life, the GL-6942 should be put in operation with rated heater voltage. After the circuit has been adjusted for proper tube operation the heater voltage should be reduced to a value slightly above that at which circuit performance is affected. At a frequency of 900 megacycles and with typical operating conditions the heater voltage can be reduced to approximately 5.3 volts. At lower frequencies, the reduction will be less. Minor circuit readjustment may be necessary after this adjustment.

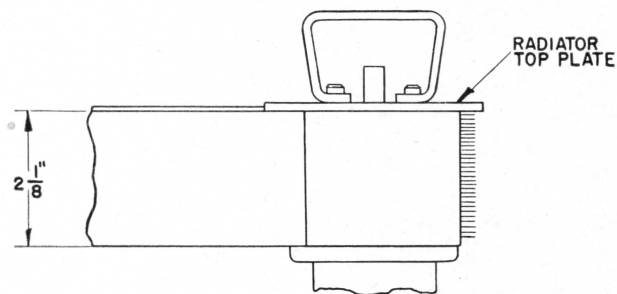
TECHNICAL INFORMATION (CONT'D)

- † Represents maximum useable cathode current (plate current plus current to each grid) for any condition of operation.
- ‡ Measured with complete external shielding between cathode and anode.
- § Output capacitance measured between anode and screen grid. Control grid connected directly to screen grid.
- ¶ The volume of cooling air indicated for the various seals is for sea-level conditions and approximate only. Distribution of cooling air will vary with the cavity configuration about the tube. For most satisfactory operation the maximum temperature of any point on the tube should be below 200 C.
- φ Useful power output including power transferred from driver stage.
- ◆ The carrier of the driver modulated 100 percent.
- ▲ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 percent of the carrier conditions.
- ♥ Total anode power output including power transferred from driver stage.
- ⊕ Denotes a change.

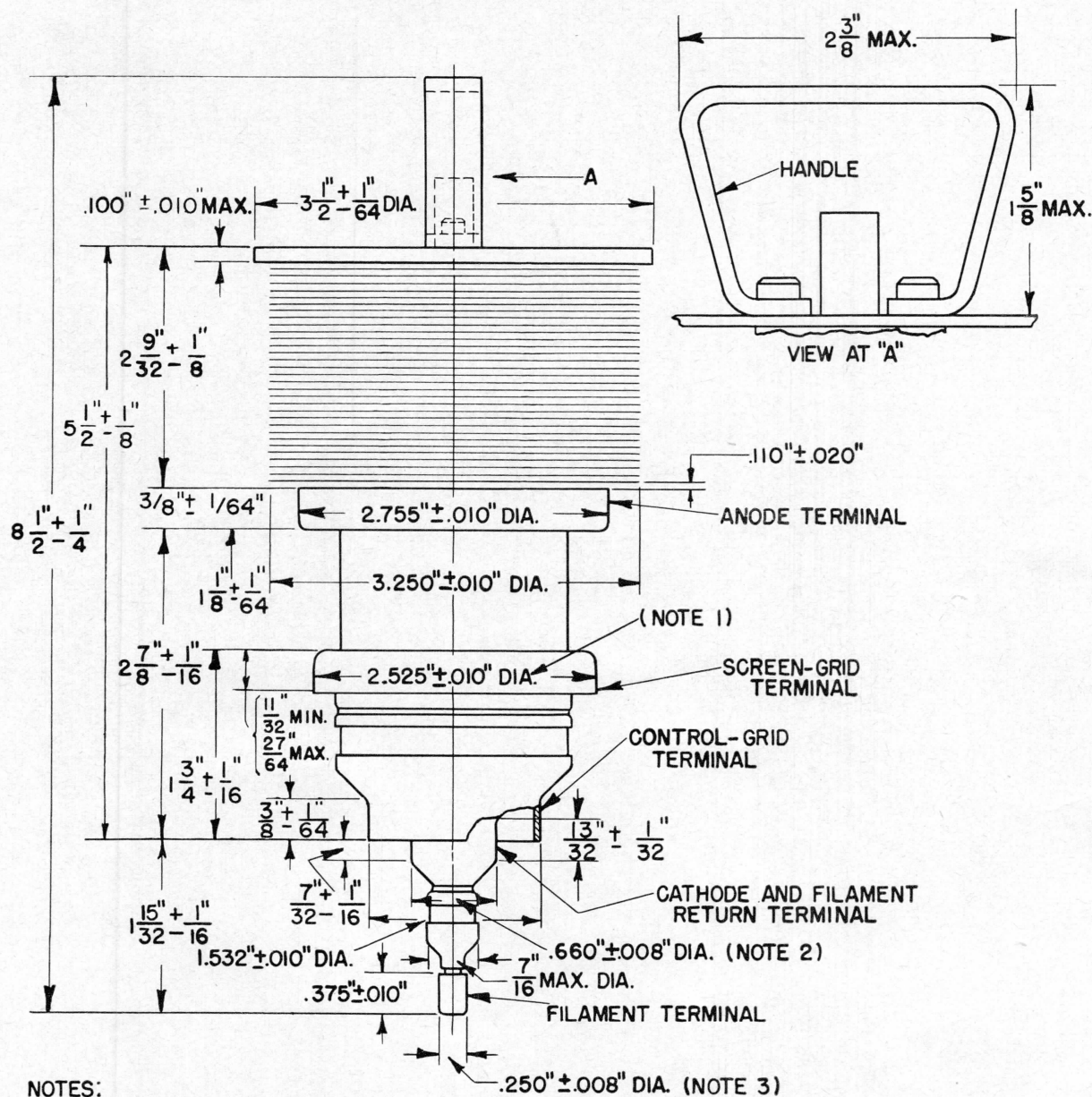
BLOWER DUCT



TOP VIEW

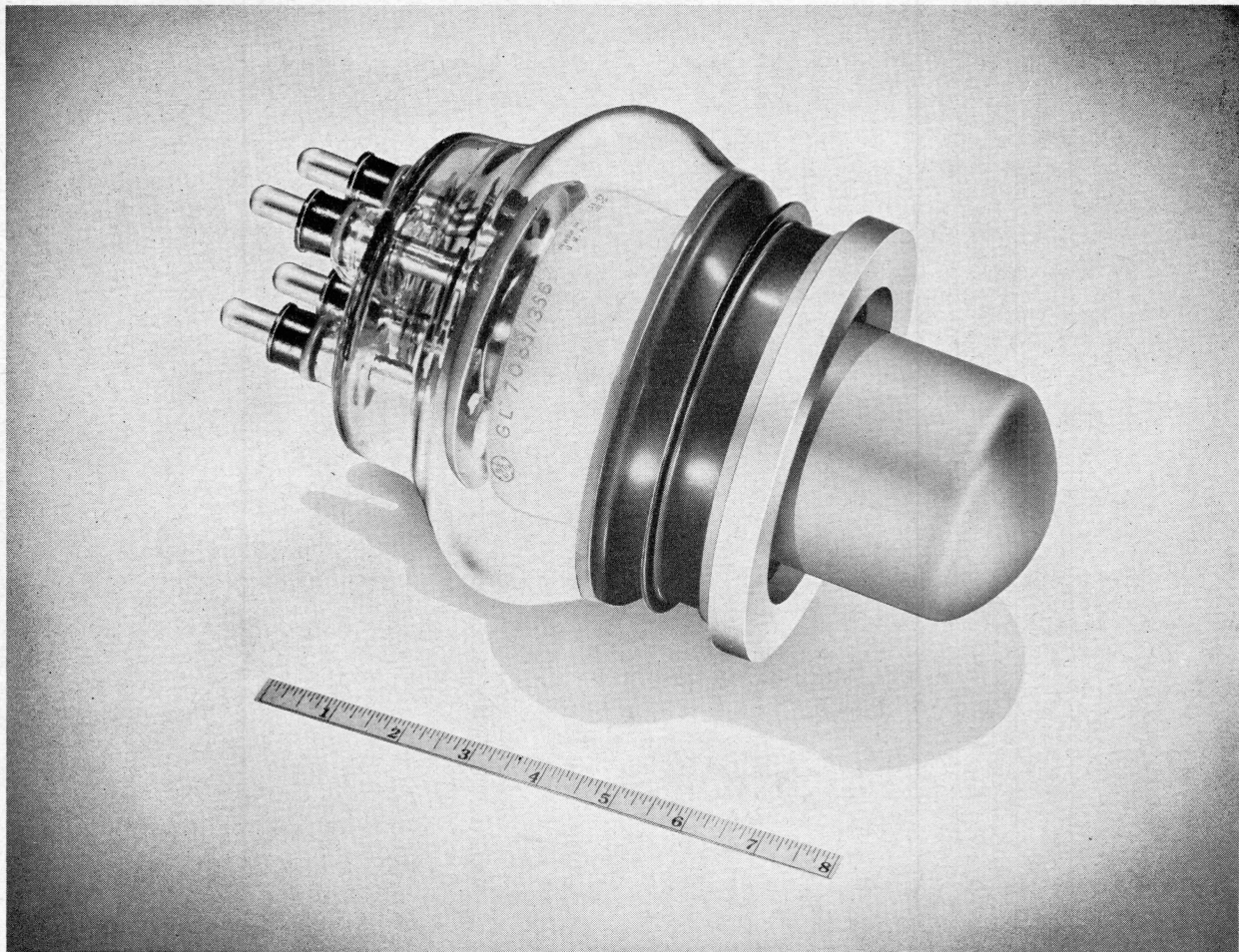


SIDE VIEW (WITH TUBE IN PLACE)



ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
Schenectady 5, N. Y.

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TRIODE

THORIATED-TUNGSTEN FILAMENT

WATER AND FORCED-AIR COOLING

MAXIMUM RATINGS UP TO 25 MEGACYCLES

The GL-7085/356 is a three-electrode tube designed for induction and dielectric heating as well as broadcast use. A thoriated-tungsten-filament version of the GL-880, the tube features a free-hung or self-supporting filament and a glass envelope incorporating rugged fernico-to-glass seals throughout. The anode is water cooled and is

capable of dissipating 22.5 kilowatts with a water flow of approximately 12 gallons per minute. Maximum ratings of 12.5 kilovolts d-c plate voltage and 60 kilowatts plate input apply at frequencies up to 25 megacycles; operation at 50 megacycles is permissible with voltage and input reduced to three-quarters maximum ratings.

TECHNICAL INFORMATION

GENERAL

Electrical

Filament Voltage.....	7.5 $\pm$ 5%	Volts
Filament Current at 7.5 Volts.....	.170	Amperes
Filament Starting Current, maximum.....	.800	Amperes
Filament Cold Resistance.....	0.0056	Ohms
Amplification Factor.....	20	
Interelectrode Capacitances		
Grid-to-Plate.....	24.5	μ f
Grid-to-Filament.....	.35	μ f
Plate-to-Filament.....	2.5	μ f

Mechanical

Mounting Position—Vertical, Anode Down

Net Weight, approximate..... 7 Pounds

GENERAL  ELECTRIC

TECHNICAL INFORMATION (CONT'D)

Thermal

Type of Cooling—Water and Forced Air

Water Flow on Anode

Minimum for 22.5 Kilowatts Dissipation.....	12	Gallons per Minute*
Maximum Outgoing Water Temperature.....	70	C
Air Flow on Dish from 3-Inch-Diameter Nozzle.....	50	Cubic Feet per Minute†

Air flow should be directed vertically downward to provide uniform distribution over the dish with nozzle as close as free air circulation permits.

Maximum Glass Temperature.....	165	C
--------------------------------	-----	---

Air and water cooling should continue for a minimum of 5 minutes after removal of power.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

AUDIO-FREQUENCY POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum Ratings, Absolute Values

DC Plate Voltage.....	12,500	Volts
Maximum Signal DC Plate Current‡.....	5	Amperes
Maximum Signal Plate Input‡.....	45	Kilowatts
Plate Dissipation.....	22.5	Kilowatts

Typical Operation, values are for two tubes

DC Plate Voltage.....	12,500	Volts
DC Grid Voltage.....	— 600	Volts
Peak AF Grid-to-Grid Voltage.....	1900	Volts
Zero-Signal DC Plate Current.....	1	Amperes
Maximum Signal DC Plate Current.....	6.4	Amperes
Effective Load Resistance, plate to plate.....	4400	Ohms
Maximum Signal Driving Power, approximate§.....	430	Watts
Maximum Signal Power Output, approximate.....	55	Kilowatts

RADIO-FREQUENCY POWER AMPLIFIER—CLASS B TELEPHONY

Carrier Conditions per Tube for Use With a Maximum Modulation Factor of 1.0

Maximum Ratings, Absolute Values

DC Plate Voltage.....	12,500	Volts
DC Plate Current.....	4	Amperes
Plate Input.....	33	Kilowatts
Plate Dissipation.....	22.5	Kilowatts

Typical Operation

DC Plate Voltage.....	12,500	Volts
DC Grid Voltage.....	— 625	Volts
Peak RF Grid Voltage.....	625	Volts
DC Plate Current.....	2.4	Amperes
DC Grid Currentϕ.....	0	Amperes
Driving Power, approximateΔϕ.....	1070	Watts
Power Output, approximate.....	12	Kilowatts

PLATE MODULATED RADIO-FREQUENCY POWER AMPLIFIER—CLASS C TELEPHONY

Carrier Conditions per Tube for Use With a Maximum Modulation Factor of 1.0

Maximum Ratings, Absolute Values

DC Plate Voltage.....	10,000	Volts
DC Grid Voltage.....	— 2000	Volts
DC Plate Current.....	4	Amperes
DC Grid Current.....	0.8	Amperes
Plate Input.....	40	Kilowatts
Plate Dissipation.....	15	Kilowatts

Typical Operation

DC Plate Voltage.....	10,000	Volts
DC Grid Voltage**.....	— 840	Volts
Peak RF Grid Voltage.....	1440	Volts
DC Plate Current.....	3.8	Amperes
DC Grid Current, approximateϕ.....	0.78	Amperes
Driving Power, approximateϕ.....	1010	Watts
Power Output, approximate.....	29	Kilowatts

TECHNICAL INFORMATION (CONT'D)

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

Key-Down Conditions per Tube Without Modulation***

Maximum Ratings, Absolute Values	Frequency 25 Megacycles			Frequency 2 Megacycles	
DC Plate Voltage.....	12,500			15,000	Volts
DC Grid Voltage.....	—2000			—2000	Volts
DC Plate Current.....	6			6	Amperes
DC Grid Current.....	0.8			0.8	Amperes
Plate Input.....	60			67.5	Kilowatts
Plate Dissipation.....	22.5			22.5	Kilowatts
Typical Operation					
DC Plate Voltage.....	10,000	10,000	12,500	15,000	Volts
DC Grid Voltage.....	—1150	—1300	—1400	—1500	Volts
Peak RF Grid Voltage.....	1810	2080	2060	2130	Volts
Peak RF Plate Voltage.....	7900	7600	9900	12,500	Volts
DC Plate Current.....	4.5	5.6	4.7	4.4	Amperes
DC Grid Current, approximate ϕ	0.55	0.72	0.42	0.37	Amperes
Driving Power, approximate ϕ	.960	1440	850	770	Watts
Power Output, approximate.....	.32	38	42	51	Kilowatts

* This flow for jackets with spiral water deflector. Older straight-wall jackets will require 16.2 gallons per minute at 22.5 kilowatts.

† At frequencies above 10 megacycles special attention should be given to adequate ventilation of the dish and seals to keep the temperature at the hottest point below 165 C. Heat-radiating connectors for grid and filament posts are recommended when tube operation is at frequencies greater than 10 megacycles.

‡ Averaged over any audio-frequency cycle of sine-wave form.

§ The driving stage should have good regulation and should be capable of supplying considerably more than the specified driving power.

ϕ Subject to wide variations depending on the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits require less grid current and driving power but sacrifice plate-circuit efficiency. The driving stage should have a tank circuit with good regulation and should be capable of supplying considerably more than the required driving power.

Δ At crest of audio-frequency cycle with modulation factor of 1.0.

** Obtained by grid resistor of 1075 ohms or by partial self-bias methods.

*** Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 percent of the carrier conditions.

MAXIMUM FREQUENCY VS RATINGS

The GL-7085/356 will operate at maximum ratings in all classes of service at frequencies as high as 25 megacycles. The tube will operate at higher frequencies provided the maximum values of plate voltage and plate input are reduced according to

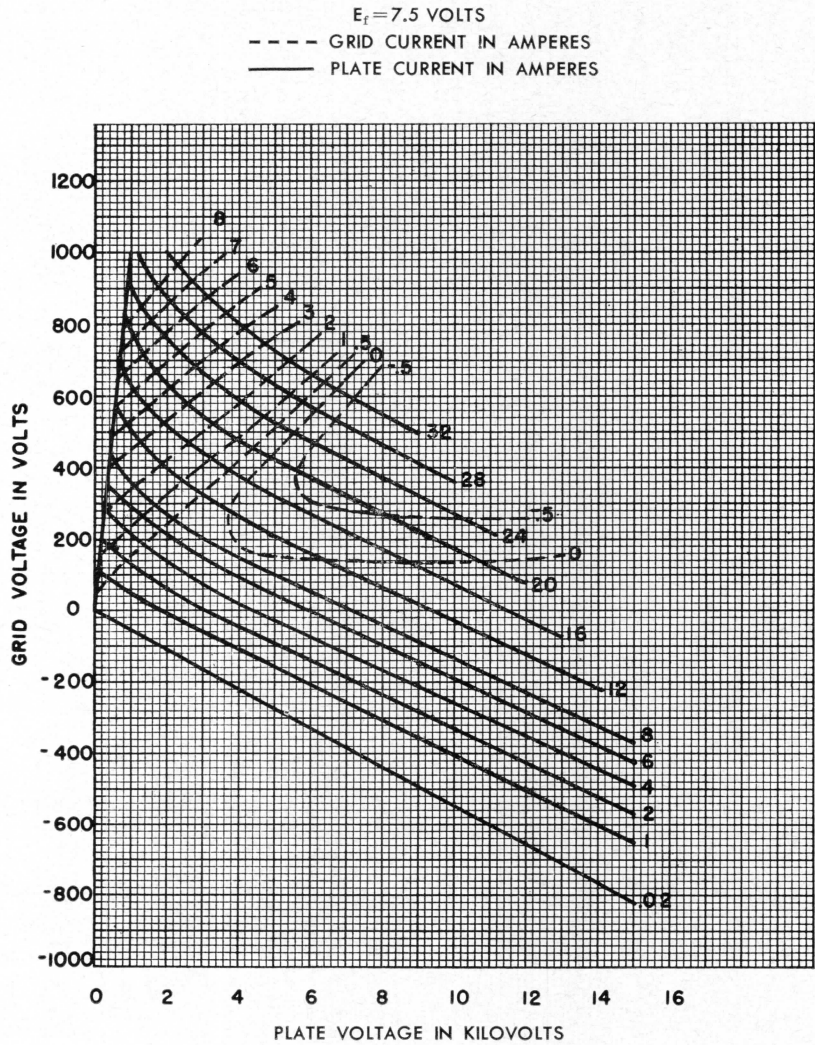
the tabulation below. In Class C Telephony service at frequencies below 2 megacycles, the plate voltage and input can be increased as indicated over the maximum values permissible at 25 megacycles.

Frequency Megacycles	Class of Service	Percentage of Maximum Rated Plate Voltage and Plate Input	
		Plate Voltage	Plate Input
25	B, C—Telephony, C—Telegraphy	100	100
50	B	80	94
	C—Telephony	75	75
	C—Telegraphy	75	75
2	C—Telegraphy	120	112.5

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

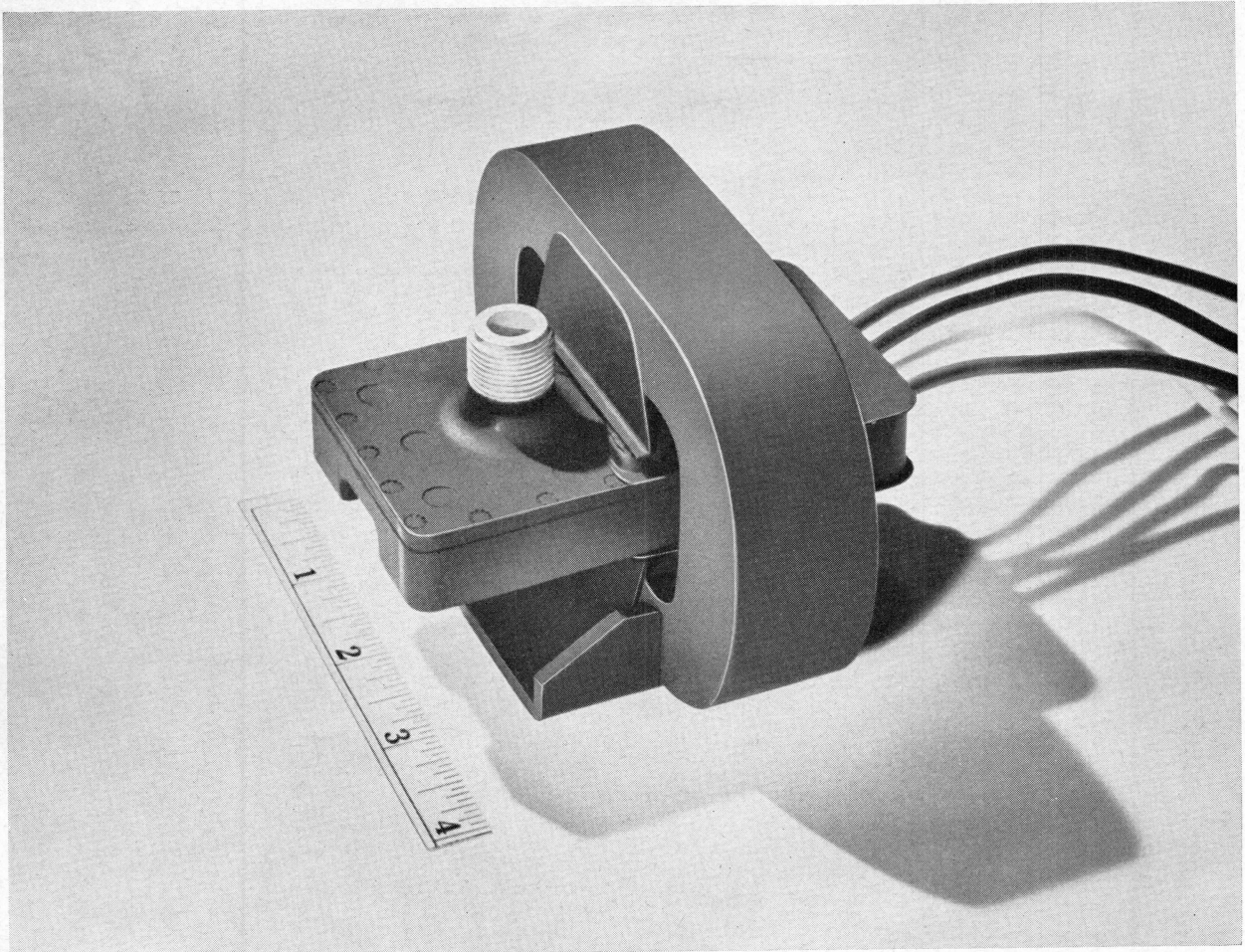
Characteristics	Conditions	Limits	
		Minimum	Maximum
Grid Voltage	ib = 28 Amp; eb = 1800 Volts	ec: ...	1100 Volts
Grid Current	ib = 28 Amp; eb = 1800 Volts	ic: ...	10.0 Amperes
Plate Voltage	Ib = 2.0 Amp d-c; Ec = 0	Eb: 2.5	3.6 KV d-c
Plate Voltage	Ib = 2.0 Amp d-c; Ec = —200 Volts d-c	Eb: 6.2	8.2 KV d-c
Grid Voltage	Eb = 10 KV d-c; Ib = 0.020 Amp d-c	Ec: —460	—600 Volts d-c
Plate Power Output	Eb = 12.5 KV d-c; Ib = 4.8 Amp d-c	Po: 34	... KW
	Ic = 0.8 Amp d-c; Ec = —1440 Volts d-c;		
	F = 25 Mc		

TYPICAL CONSTANT-CURRENT CHARACTERISTICS





ELECTRONIC COMPONENTS DIVISION
GENERAL ELECTRIC
Schenectady 5, N. Y.



PACKAGED VOLTAGE-TUNABLE MAGNETRON

2200-3850 MEGACYCLES

2 WATTS CW OUTPUT

The GL-7398 is a packaged voltage-tunable magnetron designed for voltage-tunable operation in the 2200 to 3850-megacycle frequency range. It is a complete r-f power source package requiring only input power connections and an r-f power output connection and has a minimum CW power

output of two watts across the entire frequency range. The tube may be voltage-tuned over a portion or all of the frequency range for which it is designed or operated at a fixed frequency. The voltage-frequency relationship is essentially linear.

TECHNICAL INFORMATION

GENERAL

Electrical

Cathode—Directly Heated

	Minimum	Bogey	Maximum	
Filament Voltage*	2.2	2.5	2.7	Volts
Filament Current	—	3.0	—	Amperes

Mechanical

Mounting Position—Any

Net Weight.....3.5 Pounds

Thermal

Type of Cooling—Forced Air

Air Flow.....30 Cubic Feet per Minute

Ambient Air Temperature.....50 C

TECHNICAL INFORMATION (CONT'D)

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Maximum Ratings, Absolute Values

Anode Voltage	2000	Volts
Anode Current	.30	Milliamperes
Power Input, with forced-air cooling	.45	Watts
Injection Electrode Voltage	.700	Volts
Injection Electrode Current	1.0	Milliamperes
Filament Current	3.2	Amperes
Voltage Standing Wave Ratio	1.5	

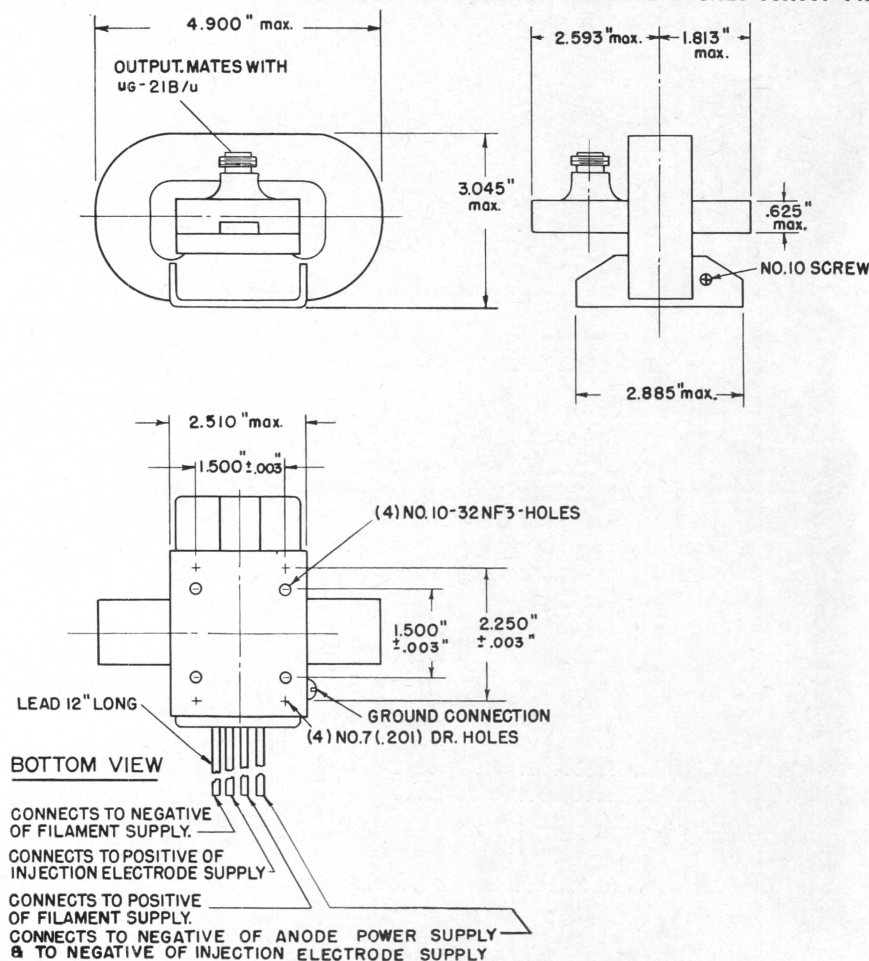
Typical Operating Conditions

Operation with 60-cycle Sweep Voltage in Wide-Band Circuit

Filament Voltage*, approximate	2.50	Volts
Filament Current	3.0	Amperes
Tunable Range†	2200—3850	Megacycles
Tuning Rate, approximate	3.0	Megacycles per Volt
Anode Voltage at 3 Kilomegacycles	1250	Volts
Anode Current, average	10 to 20	Milliamperes
Injection Electrode Voltage, positive with respect to cathode	300 to 600	Volts
Injection Electrode Current	0.1	Milliamperes
Voltage Standing Wave Ratio of Load	1.3	
Power Output, minimum	2.0	Watts
Variation over Band	Less than 4:1	

* Filament current should be adjusted to 3.0 amperes.

† Frequency controlled by anode voltage.

CAUTION: KEEP FERROUS MATERIAL AND MAGNETS AT LEAST 9 INCHES AWAY FROM PACKAGE.

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